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HEALTH ORGANISATION

PROGRESS OF THE SCIENCE OF NUTRITION IN JAPAN

BY

TADASU SAIKI

GENEVA 1926

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INTRODUCTION.

The problem of nutrition assumes many different aspects according to the angle from which it is approached. From the physiological point of view the problem may be subdivided as follows: (1) What are the organic requirements, and (2) what is the best method of meeting these requirements, that is to say, the most economical method of consumption from the standpoint of physiology ? Another aspect of the problem of nutrition is the economic one. Regarded from this angle, the problem may also be subdivided as follows: (1) The production of articles of food, and (2) the manner in which these articles may be most profitably utilised in conformity with the economic resources of each country.

The fault to be found with most enquiries which have hitherto been conducted into the problem of nutrition is that they have not taken into account the interdependence of these two aspects, and have endeavoured to discover a solution from one point of view only. A moment's reflection will, however, suffice to convince us that the problem can receive a satisfactory solution only if the method of physiological utilisation (*i.e.*, consumption), selected as most advantageous from a physiological point of view, is also the most advantageous from the point of view of national economy.

Unfortunately, even supposing that some ideal solution be discovered which fulfils these two conditions, the solution might be rendered illusory by a third and not less important aspect of the problem — the social aspect. It is theoretically possible, and indeed it happens too often, that even when the problem of nutrition has been satisfactorily solved — as regards the above conditions — it is materially impossible to meet the food requirements of a whole social group, owing to the well-known fact that in most organised human communities there are poor as well as rich individuals.

The determination of food requirements and the most effective methods of satisfying these requirements from a physiological point of view will not, even if the method also happens to be the best one from the point of view of national economy, suffice to eliminate the phenomenon of hunger. Certain articles of food which from the standpoint of physiology and national economy are entirely satisfactory, are often so expensive as to be inaccessible to the masses. A scientific working plan which would make it possible to arrive at a real solution of the problem of nutrition should therefore have three main objects in view:

(1) To determine what natural products can satisfy food requirements, and then select those the consumption of which would be most advantageous from a purely physiological point of view;

(2) To select from the latter group the substances which best meet the requirements of national economy; and

(3) Proceed, in this last group, by selection based on social considerations, to draw up a " food code " which, though it may not be perfect, will, under existing social conditions, be the nearest approach to perfection we can attain.

The State Institute for the Study of Nutrition, which was founded at Tokyo in December 1920, and of which I was appointed Director, proposes to conduct researches on these lines. The Institute includes four departments, organised as follows:

Department I: Theoretical Study of the Science of Nutrition:

Section 1: Alimentary chemistry.
Section 2: Metabolism.
Section 3: Physiology and pathology.
Section 4: Miscroscopy.
Section 5: Physics.

Department II: Practical Study of the Science of Nutrition:

Section 1: Study of foodstuffs:

(*a*) Natural products (including substitutes employed in time of famine);
(*b*) Food industries;
(*c*) Research with a view to the discovery of new foodstuffs, animal or vegetable.

Section 2: Cheap food.
Section 3: The preservation and distribution of foodstuffs.
Section 4: Kitchen and table utensils.
Section 5: The feeding of infants.
Section 6: The utilisation of refuse.

Department III: Research Work:

Section 1: Statistical and historical studies.
Section 2: Practical courses in nutrition; exhibitions and propaganda.

Department IV: Central Services:

Section 1: Staff, correspondence, etc.
Section 2: Supplies and accountancy.

This Institute is no case of spontaneous growth. On the contrary, it is the last link in the long chain of effort made by generations of Japanese scientists. Japan as a country is relatively small and poor; the question of her food supplies has at all times been an agonising problem for statesmen and hygienists alike. At certain times, for instance during the Tagukawa period, the population of its own accord endeavoured to remedy the situation by voluntarily limiting the number of births; for the last fifty years, however, there has been no sign of this tendency.

In the past, Japan was entirely dependent on food supplies from abroad and

famine with all its consequences was of frequent occurrence; but, during the last fifty years, the modern development of the country, its agriculture and industry, has to a large extent rendered it independent of foreign supplies, and food conditions have considerably improved. At the present time the food resources of the country consist of 400 varieties of common foodstuffs, to which must be added about 500 varieties of foodstuffs which can be employed in time of emergency. All these foodstuffs—those which are commonly used by the people and those which it would seem need only be used in exceptional circumstances — should be studied from the point of view of their chemical composition, their production and improved methods of utilisation if the country is to be spared the privations it has endured in the past.

It is, indeed, this urgent need to ensure regular food supplies which has stimulated the great efforts, both in pure and in applied science, of Japanese scientists, such as Professor Osawa, of the Imperial University of Tokyo; Dr. Tawara, of the Ministry of the Interior's Station of Experimental Hygiene; Dr. Mori and Baron Takagi, who have devoted their energies to improving the food supply of the army and the fleet; Professors Oshima, Suzuki and Tsuzuki, and many others.

The present volume consists of the work of Japanese scientists in the various institutions of the country, particularly the State Institute for the Study of Nutrition, of which I have the honour to be Director. I have selected from among these works those which are of general utility and, I venture to hope, of a scientific interest outside the narrow limits of our land. These works represent a part of what is best in Japanese scientific contributions to this subject.

Tokyo, December 1926. Saiki.

* * *

To give an idea of the diversity of the work undertaken, I quote about a hundred records of research work published during the last few years.

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1.

THE BASAL METABOLISM OF NORMAL JAPANESE MEN AND WOMEN

By Hideo Takahira.

(From the Imperial State Institute for Nutrition, Tokyo.)

1. Introduction.

Every man and woman has a basal metabolism. The term " basal metabolism " means the minimal heat production of an organism measured while it is in the post-absorptive condition and during muscular repose. It was first described by Magnus-Levy under the term " Grundumsatz " and in the past decade it has been extensively studied in America, especially by Dr. Benedict and his collaborators of the Nutrition Laboratory of the Carnegie Institution of Washington, and Dr. Du Bois and his staff of the Russel Sage Institute of Pathology, Bellevue Hospital.

Since the establishment of our Institute in 1921, I have been engaged in the determination of the basal metabolism of normal Japanese men and women. In this report, I propose to present the results of studies made on 120 adult men and women, and to analyse the data by the biometric method.

2. Experimental Apparatus and Procedure.

The experimental apparatus used was a respiration apparatus for clinical use, devised by Benedict and Tompkins and constructed by Collins of Boston.

The apparatus is one of the closed circuit respiration apparatus of the Regnault and Reiset type and is adapted for experiments of long duration. It consists of a large respiration chamber, universal respiration apparatus and accessory apparatus, namely, gas-meter, balance and barometer, etc. The heat production is calculated indirectly from the oxygen consumption and the carbon dioxide production. A detailed account of the apparatus and the experimental technique may be found in Benedict and Tompkins' article.

First of all, I tested the apparatus with several alcohol check tests and proved that the R.Q. had nearly the correct theoretical value, that is, 0.666. During the course of the human experiments I used the alcohol check test once a week.

The experimental subjects used were selected and divided into the following groups:

1. Ten policemen, from the Metropolitan Police Board.
2. Eleven primary-school teachers in Tokyo.
3. Eleven electric-car conductors and motor-men, of the Tokyo Electric Car Company.
4. Nine barbers, working in various barbers' shops in Tokyo.
5. Eight labourers, usually working out of doors.
6. Nine scholars and office workers, members of the Institute, journalists, school inspectors, etc.
7. Nine factory workmen.
8. Six merchants, dealers in glassware, medical instruments and drugs.

The female subjects were as follows:

9. Sixteen primary-school teachers in Tokyo.
10. Sixteen office girls, from the statistical department of the Tokyo City Office.
11. Eleven labourers, doing physical work in the Army Commissary Department.

The experimental subjects were kept in a room of the Institute over night. At 6 p.m., on entrance, they were given a test meal, with an energy value of 877 calories and containing 5.213 gms. protein in the case of men, or 751 calories, and 4.807 gms. protein in the case of women. The next day, 15 to 18 hours after the last meal, a series of experiments were carried out, with the respiration apparatus, from 9 a.m. to noon. The experimental periods were divided into a preliminary and four subsequent principal periods. Each period continued for half an hour.

3. Experimental Results.

The experiments extended from March 6th, 1921, to February 6th, 1922. The following points were particularly noticed in each experiment: (1) age, (2) body weight, (3) body height, (4) body surface area computed from Du Bois' height-weight formula, (5) quantity of oxygen consumed per hour, (6) quantity of carbon dioxide produced per hour, (7) respiratory quotient, (8) quantity of urine nitrogen per hour, (9) calories produced per hour, (10) calories produced per 24 hours, (11) calories produced per kilogram of body weight per 24 hours, (12) calories produced per square meter of body surface per hour, (13) pulse rate, (14) respiration rate.

The individual data are presented in the attached table (see inset).

4. Biometric Measurements.

The results of the individual measurements were varied and confused, and it was necessary to find a general rule, a law of variation and the correlation of the various physical and physiological characters. I treated my results with biometric formulæ. A biometric study of human basal metabolism was first performed by Benedict and Smith, and my own statistical method is based largely on their work.

The statistical constants to be determined are the average mean, the standard deviation, the variation coefficient, the correlation coefficient and their probable errors.

The experimental subjects considered are 77 men and 43 women. The following table represents the physical and physiological characters taken into account. The symbol in parenthesis is the one used to designate the particular measurement in the statistical formulæ.

Table 2. — Statistical Constants and their Probable Errors.

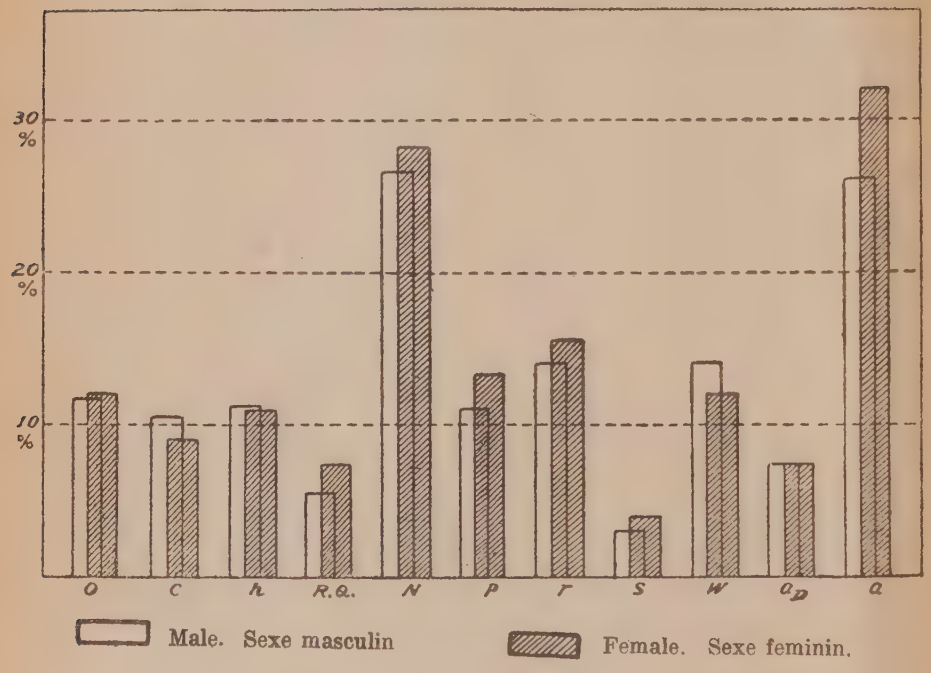
		Sexe Sex	Moyenne Average mean	Ecart quadratique moyen Standard deviation	Coefficient de variabilité Variation coefficient
Taille	(*h*)	M.	158.6±12.35	5.053±0.2782	3.19±0.1756
Body height . . .		F.	147.4±15.16	5.868±0.4268	3.98±0.2895
Poids	(*w*)	M.	53.54±4.170	7.567±0.4166	14.14±0.7785
Body weight . . .		F.	45.55±4.686	5.606±0.4077	12.31±0.7855
Superficie du corps .	(a^D)	M.	1.529±0.1191	0.1132±0.0062	7.40±0.4074
Body surface area .		F.	1.352±0.1391	0.1003±0.0073	7.42±0.5397
Age	(*a*)	M.	31.2±2.430	8.097±0.4458	25.95±1.429
		F.	30.2±3.122	9.641±0.7012	31.92±2.257
Consommation d'oxygène . . .	(*o*)	M.	11.93±0.9292	1.419±0.0781	11.89±0.6549
Oxygen consumption		F.	9.56±0.9834	1.154±0.0804	12.07±0.8778
Production de CO^2 . Carbon dioxide production	(*c*)	M.	10.24±0.7975	1.093±0.0610	10.67±0.5675
		F.	8.38±0.8620	0.7672±0.0545	9.16±0.6662
R. Q..		M.	0.86±0.0669	0.0482±0.0027	5.60±0.3083
		F.	0.89±0.0915	0.0668±0.0049	7.50±0.5454
N. éliminé dans l'urine Urine nitrogen excretion	(*n*)	M.	0.4021±0.0313	0.1066±0.0059	26.51±1.461
		F.	0.3161±0.0325	0.0911±0.0066	28.82±2.024
Production de chaleur par 24 h. . Heat production per 24 hours	(*h*)	M.	1373±106.9	156.1±8.579	11.37±0.6260
		F.	1073±110.4	117.1±8.516	10.91±0.7956
Pouls	(*p*)	M.	56±4.421	6.329±0.3534	11.30±0.6304
Pulse rate		F.	64±7.514	8.540±0.7090	13.34±1.108
Respiration	(*r*)	M.	16±1.362	2.239±0.1232	13.99±0.7702
Respiration rate . .		F.	16±1.646	2.487±0.1809	19.54±1.130

The results show that in the average man of 158.6 cms. body height, 53.54 kgms. body weight, 1.529 sq.m. body surface area, and 31.2 years of age, there is a basal heat production of 1,373 calories. The average respiratory quotient is 0.86. The average excretion of urine nitrogen is 0.4021 gms. The average basal pulse rate is 56 and the respiration rate is 16. In the average woman of 147.4 cms. body height, 45.55 kgms. of body weight, 1.352 sq.m. body surface area, and 30.2 yrs. of age, there is a basal heat production of 1,073 calories. The average respiratory quotient is 0.89. The average excretion of urine nitrogen 0.3101 gms. The average

basal pulse rate is 64, and the respiratory rate is 16. It is noticed that the respiratory quotient and the pulse rate in female subjects are a little higher than in male subjects. This probably is due to the emotional excitability of the female subjects.

A comparison of the variation coefficients of the various physical and physiological characters is charted in Diagram 1. The variation coefficients of body height, R.Q. and body surface area are relatively small. The variabilities of body weight, oxygen consumption, carbon dioxide production, heat production, pulse rate, and respiration rate are nearly 10 per cent. The variabilities of the basal gaseous exchange and heat production are slightly smaller than those of pulse and respiration rate. The excretion of urine nitrogen and the age are the most variable factors.

Diagram 1. — Comparison of the Variation Coefficients of Physical and Physiological Characters.



The correlation coefficients between the physical and the physiological characters have been determined and are represented in Table 3. The physical characters considered are the body height, the body weight, the body surface area and the age, and the physiological characters considered are the oxygen consumption, the carbon dioxide production and the heat production. The correlation between them is represented in Table 4 by means of the ratio of the correlation coefficients and their probable errors. In Diagrams 2 to 7 is also represented the correlation between the physical characters and the heat production. Although there may be a certain correlation between the physiological characters reciprocally, *e.g.*, between the metabolism and the pulse rate, it has not been determined.

Table 3. — Correlation Coefficients.

	Sexe Sex	*s*	*w*	a^D	*a*
o	M.	0.5929±0.0505	0.8274±0.0213	0.8606±0.0202	—0.0174±0.0779
	F.	0.3173±0.0933	0.5136±0.0757	0.5028±0.0769	—0.5279±0.0742
c	M.	0.5043±0.0581	0.8173±0.0259	0.8045±0.0275	—0.0515±0.0777
	F.	0.0850±0.1021	0.4266±0.0841	0.4550±0.0811	—0.4079±0.0857
h	M.	0.5800±0.0517	0.7794±0.0306	0.8628±0.0199	—0.0537±0.0777
	F.	0.3659±0.0890	0.5479±0.0720	0.5674±0.0595	—0.4693±0.0802

Table 4. — Correlation expressed in $\frac{\gamma}{E^{\gamma}}$.

	Sexe Sex	*s*	*w*	a^D	*a*
o	M.	11.73	38.91	42.60	0.22
	F.	3.40	6.78	6.54	7.12
c	M.	8.68	31.58	29.28	0.66
	F.	0.83	5.07	5.61	4.64
h	M.	11.22	25.48	43.33	0.69
	F.	4.11	7.61	9.54	5.85

Diagram 2. — The Correlation between Heat Production and Body Height (Male).

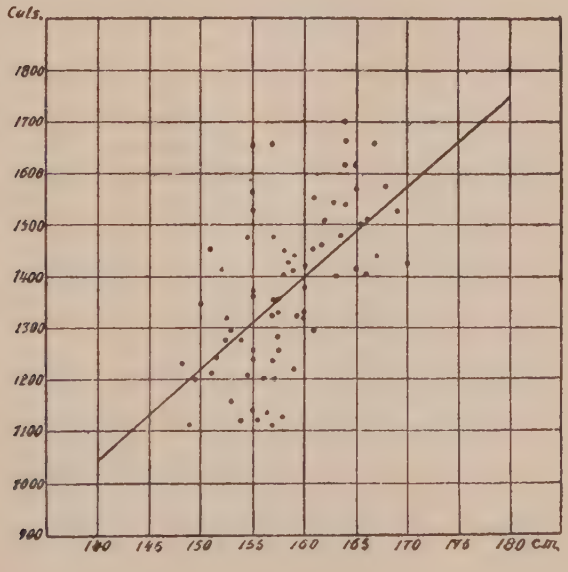


Diagram 3. — The Correlation between Heat Production and Body Weight (Male).

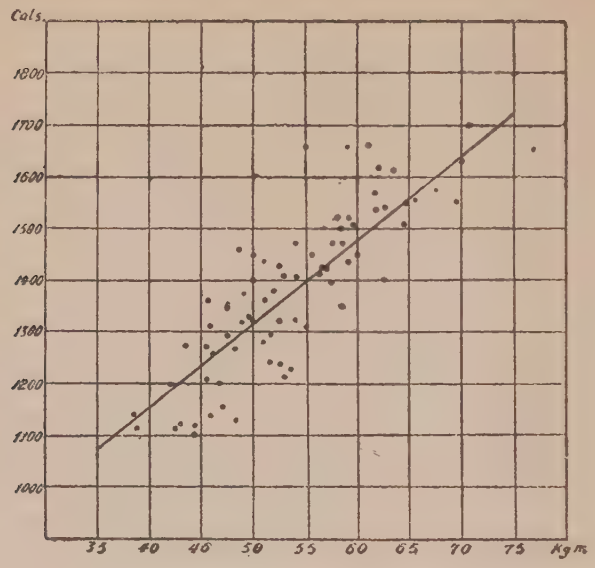


Diagram 4. — The Correlation between Heat Production and Body Surface Area (Male).

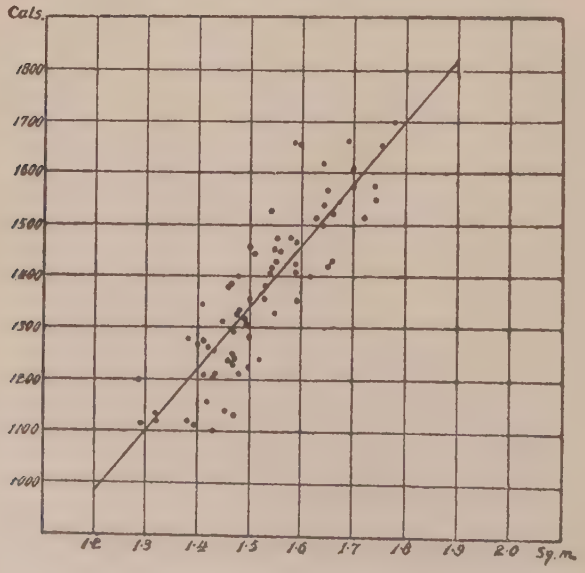


Diagram 5. — The Correlation between Heat Production and Body Height (Female).

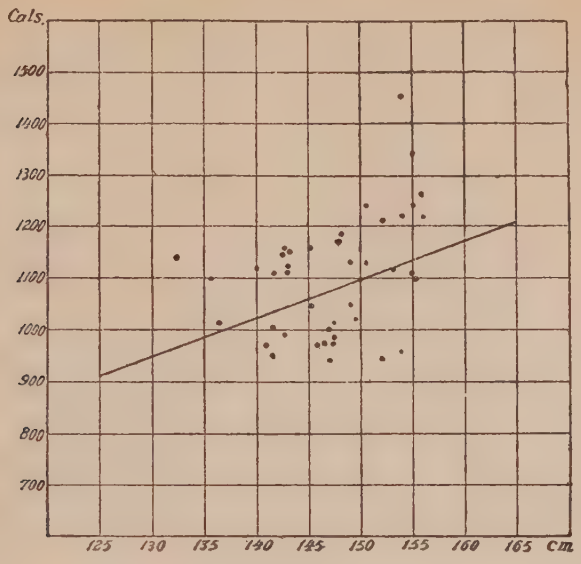


Diagram 6. — The Correlation between Heat Production and Body Weight (Female).

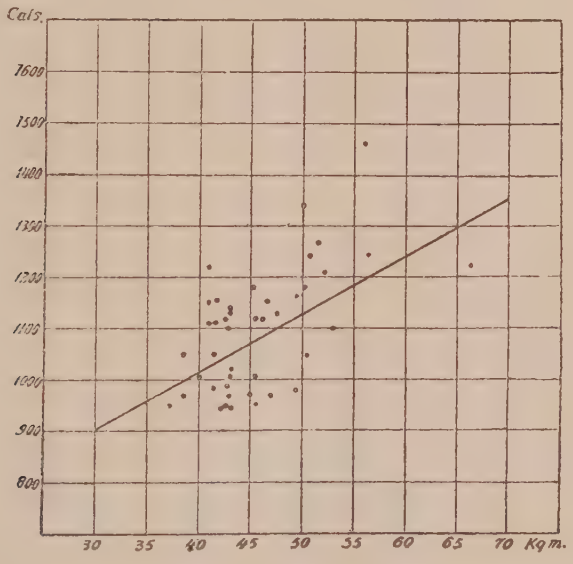
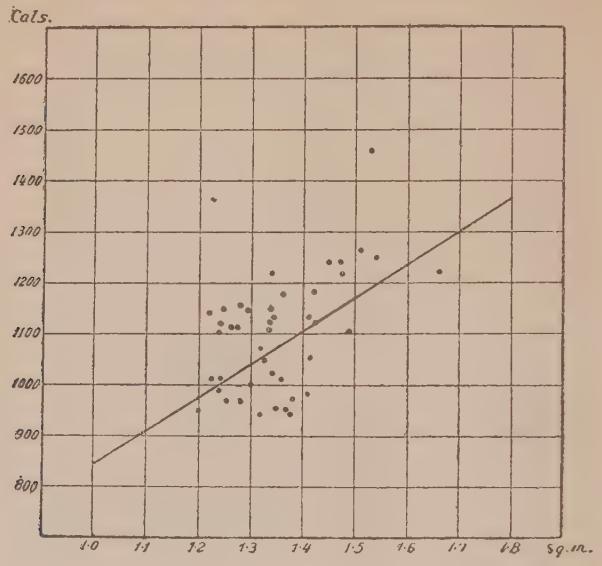


Diagram 7. — The Correlation between Heat Production and Body Surface Area (Female).



The correlation coefficients of the body height, the body weight, and the body surface area to the metabolism are all positive in sign, but the coefficient of age is negative in sign. This means that the metabolism decreases as the age advances.

The correlation coefficients of male subjects are generally higher than those of female subjects. In both sexes the body surface area has a most intimate correlation with the metabolism. The correlation between age and metabolism is different in the two sexes; in female subjects the correlation coefficient is from 0.4 to 0.5, but in male subjects there is no significant correlation. This is due to the mode of selection of the subjects.

5. Discussion of the Results.

(1) *Critique of the Body Surface Law.*

The heat production of man and animals depends largely upon their size, but it is not directly proportional to the body weight. A large man gives off more heat than a small man; but for each kilogram of body weight a small person produces more heat than a large one. On the other hand, the metabolism of man and animals of various sizes and shapes is fairly closely proportional to the surface area of the body. In 1883, Rubner established this law of body surface area and was able to show that mice, rabbits, dogs, men and horses have almost the same metabolism per square

meter of body surface. The principle embodied in this law is that the basal metabolism is a simple function of the body surface area. Even after the establishment of this principle, however, investigators were handicapped for years through the lack of an accurate method for measuring or calculating the body surface area.

Eugene F. Du Bois, in collaboration with Delafield Du Bois, devised the linear formula in 1915, and the height-weight formula in 1916. Using these formulæ, Du Bois proved that the body surface law holds true in the case of human basal metabolism. But a criticism that there is no relationship between body surface area and the metabolism has been brought forward by Benedict.

Calculated from my results, the correlation coefficients between the heat production and the body weight or the body surface area are as follows:

$$\text{Male} \quad \gamma^{wh} = 0.7794 \pm 0.0306, \frac{\gamma}{E^{\gamma}} = 25.48$$

$$\gamma^{aDh} = 0.8628 \pm 0.0199, \frac{\gamma}{E^{\gamma}} = 43.33$$

$$\text{Female} \quad \gamma^{wh} = 0.5479 \pm 0.0720, \frac{\gamma}{E^{\gamma}} = 7.61$$

$$\gamma^{aDh} = 0.5674 \pm 0.0595, \frac{\gamma}{E^{\gamma}} = 9.54$$

It is apparent that the body surface area is more closely related to the heat production than the body weight.

The average basal heat production per square meter of body surface per hour in the adult Japanese is 37.33 calories for males, and 33.84 calories for females. The average heat production per kilogram of body weight per day is 25.84 calories for males and 24.12 calories for females. The statistical constants determined worked out as follows:

Male	Surface unit	Weight unit
Average mean	37.33 ± 2.907	25.84 ± 2.013
Standard deviation	2.340 ± 0.1288	1.915 ± 0.1054
Variation coefficient	6.27 ± 0.3452	7.41 ± 0.4080
Female		
Average mean	33.84 ± 3.481	24.12 ± 2.481
Standard deviation	2.928 ± 0.2129	2.417 ± 0.1758
Variation coefficient	8.65 ± 0.6291	10.02 ± 0.7284

In males, the variation coefficient of a surface unit is 6.27 and that of a weight unit is 7.41 per cent. In females they are 8.65 and 10.02 per cent respectively. Thus the basal metabolism expressed in the surface unit is less variable than that expressed in the weight unit.

According to Du Bois, Means, Labbé and Stévenin, an obese person has a lower metabolism than a thin person per weight unit, but there is no difference in the metabolism per surface unit. To examine this point, I have taken the metabolism of ten obese men and compared it with the average value according to the surface and weight units respectively. The grade of obesity is simply expressed in the ratio of the body height and body weight.

Table 5.

Sujet Subject	h /w	Unité de poids Weight unit			Unité de superficie Surface unit		
		Calories	Deviation	Deviation %	Calories	Deviation	Deviation %
Maniwa	2.36	23.87	—1.97	— 8	39.49	+2.16	+ 5
Ibuka	2.86	22.83	—3.01	—13	34.07	—3.26	—10
Itagaki	2.52	24.16	—1.68	— 7	38.72	+1.39	+ 4
Itagaki	2.31	22.16	—3.68	—17	37.15	—0.28	— 1
Hoshino	2.68	24.97	—0.87	— 3	38.24	+0.91	+ 2
Kobayashi	2.75	22.81	—3.03	—13	34.88	—2.45	— 7
Honda	2.50	23.51	—2.23	—10	36.68	—0.65	— 2
Toyama	2.61	25.47	—0.37	— 1	39.64	+2.31	+ 6
Kikuchi	2.43	23.27	—2.57	—11	37.78	+0.45	+ 1
Ito	2.02	21.49	—4.35	—20	39.17	+1.84	+ 5
Moyenne Average	—	—	—2.39	—11	—	+0.28	+ 0.3

With the weight unit the basal metabolism is 11 per cent smaller than the average value, but with the surface unit it coincides with the average value. The above results show from various points of view that the body surface law holds true in the basal metabolism of men and women.

(2) *Changes of the Metabolism according to Age.*

One would expect age to have a definite bearing on metabolism and research has proved this to be true. The level of the metabolism varies greatly with age. During the period of growth the metabolism is relatively high and in old age the metabolism is slightly decreased. Between the adult ages of 20 and 50 there is comparatively little change.

In my results the correlation coefficients between the total heat production and age are as follows:

Male . . . . . $\gamma^{ah} = 0.0537 \pm 0.0777, \frac{\gamma}{E^{\gamma}} = 0.67$

Female . . . . $\gamma^{ah} = 0.4693 \pm 0.0802, \frac{\gamma}{E^{\gamma}} = 5.85$

There is a relatively high correlation between the metabolism and age in females but no significant correlation in males. The difference in the correlation in the two sexes is not of a fundamental nature but is due to the selection of the subjects. If we consider the 30 males who were policemen, conductors and workmen instead of all 78 male subjects, there is a definite correlation between the metabolism and age:

Mean of age	= 29.8
Mean of heat production	= 1,393
Standard deviation of age	= 9.015
Standard deviation of heat production . . .	= 154.4
γ^{ah}	= 0.2331

Diagram 8. — The Correlation between Age and Heat Production (Male).

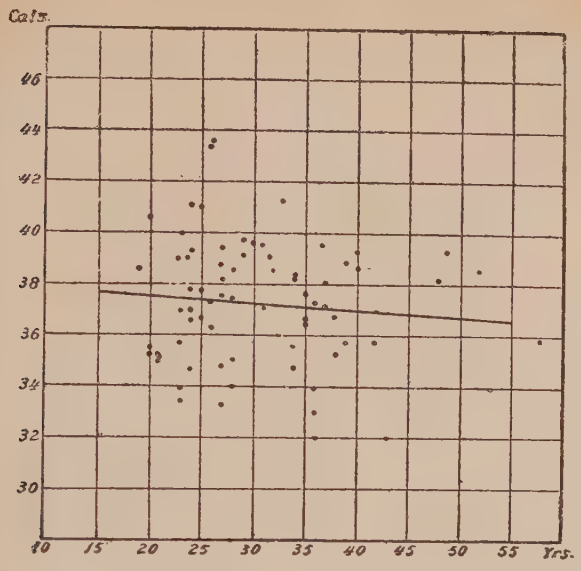
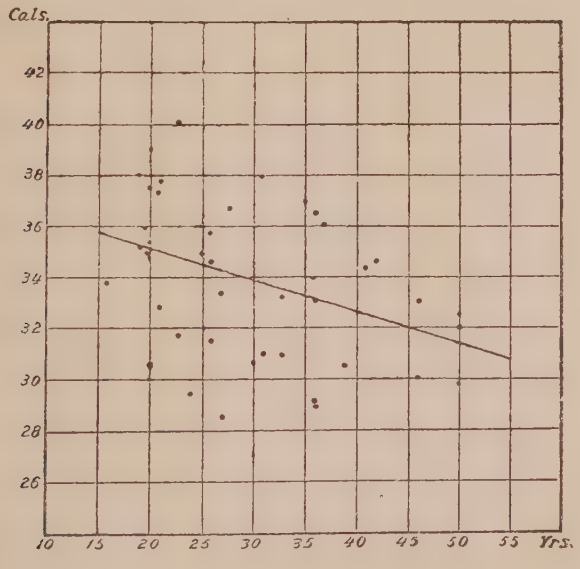


Diagram 9. — The Correlation between Age and Heat Production (Female).



According to Sondén and Tigerstedt, the correlation coefficients of carbon dioxide production and age are as follows:

$$\text{Male} \ldots \gamma^{ac} = 0.629 \pm 0.076$$
$$\text{Female} \ldots \gamma^{ac} = 0.058 \pm 0.163$$

Unlike the last case, the correlation in males is relatively high, but in females it is not significant.

We are sure that the correlation between metabolism and age does not exist invariably, but there is a definite correlation if a sufficiently large number of examples are included.

Diagrams 8 and 9 represent graphically the correlation between heat production per square meter per hour and age. The correlation coefficients are as follows:

$$\text{Male} \ldots \gamma^{ah} = 0.0947 \pm 0.0771, \quad \frac{\gamma}{E^{\gamma}} = 1.23$$

$$\text{Female} \ldots \gamma^{ah} = 0.4174 \pm 0.0849, \quad \frac{\gamma}{E^{\gamma}} = 4.91$$

(3) *Changes of Metabolism according to Sex.*

The heat production of men was higher than that of women. Comparisons between the average daily heat production, the heat production per kilogram per 24 hours and the heat production per square meter per hour were made:

	Male	Female	Difference
Daily heat production	1,373 cals.	1,073 cals.	22 %
Heat per kgm. per 24 hours .	25.84 »	24.12 »	6 %
Heat per sq. m. per hour . .	37.33 »	33.84 »	9 %

The metabolism of females was compared with the metabolism predicted by the first prediction method, which will be described later on.

The results were as follows:

Table 6.

Age	Nombre de sujets Number of subjects	Age moyen Age (average)	Taille moyenne Height (average)	Poids moyen Weight (average)	Superficie moyenne Surface area (average)	Calories (average)	Calories chez l'homme Calories in man	Difference	%
20—24	13	21.3	147.0	44.41	1.34	1131	1223	— 92	— 7.5
25—29	7	26.4	147.3	46.43	1.36	1105	1236	—131	—10.6
30—34	5	31.6	149.1	46.60	1.38	1074	1257	—183	—14.5
35—39	8	36.4	146.3	47.05	1.36	1077	1218	—141	—11.5
40—44	2	41.5	144.7	45.10	1.34	1097	1191	— 94	— 7.8
45—49	2	46.0	144.4	42.20	1.28	965	1131	—166	—14.6
Moy. Aver.	—	—	—	—	—	—	—	—	—11.1

The metabolism of men was 11 per cent higher than that of women.

(4) *Constancy of the Basal Metabolism in the same Individual.*

The basal metabolism varies according to body height, body weight, body surface area, age and sex. In the unit of body surface area corrected by the age factor, there is still individual variation. Du Bois said that the basal metabolism which varies within ± 10 per cent from individual to individual is normal. There is, however, a constant basal metabolism in the same individual on different days.

An experiment was performed on myself and my colleague, S. Kitagawa, on each of six successive days, with the following results:

Table 7. — Subject Takahira, 169 cm. Body Height, 26 Years.

Date	Poids Weight	Consommation d'O^2 O_2 consumption	Production de CO^2 CO_2 production	R. Q.	Elimination de N N excretion
May 8 mai	52.6	11.99	10.59	0.88	0.4500
9	52.2	11.89	10.37	0.87	0.3591
10	52.1	12.52	10.44	0.83	0.4009
11	52.5	11.78	10.25	0.88	0.4818
12	52.7	12.17	10.32	0.85	0.5027
13	53.0	11.49	10.40	0.91	0.5320
Moyenne – Average	52.5	11.97	10.40	0.87	0.4544

Subject Kitagawa, 161 cm. Body Height, 24 Years.

Date	Poids Weight	Consommation d'O^2 O_2 consumption	Production de CO^2 CO_2 production	R. Q.	Elimination de N N excretion
May 15 mai	51.3	11.36	9.49	0.84	0.6120
16	51.3	11.30	9.19	0.84	0.5605
17	51.7	11.34	9.41	0.83	0.4544
18	51.3	11.65	9.43	0.81	0.3261
19	51.5	11.45	9.31	0.81	0.5473
20	51.4	11.82	9.66	0.82	0.4446
Moyenne – Average	51.4	11.49	9.42	0.83	0.4908

The average basal heat production per hour of Takahira was 57.23 cals., the standard deviation was 1.334 cals., and the variation coefficient was 2.33 per cent. The basal value of S. Kitagawa was 54 cals., the standard deviation was 1.109 cals., and the variation coefficient was 2.05 per cent. The basal metabolism of the same individual was constant within the variability of about 2 per cent.

Table 8.

Jour Day	Takahira		Kitagawa	
	Nombre de calories par heure Calories per hour	Déviation Deviation	Nombre de calories par heure Calories per hour	Déviation Deviation
1	57.39	+ 0.16	53.33	— 0.67
2	57.05	— 0.18	52.67	— 1.33
3	59.56	+ 2.33	53.50	— 0.50
4	56.28	— 0.95	55.18	+ 1.18
5	57.84	+ 0.61	53.50	— 0.50
6	55.24	— 1.98	55.81	+ 1.81
Ecart moyen Mean deviation	57.23	—	54.00	—
	—	.334	—	± 1.109
Variation	—	2.33	—	2.05

6. Normal Standard of Basal Metabolism and its Application to the Experimental Results.

(1) *Normal Standard of Basal Metabolism of the Japanese.*

The importance of the normal standard of basal metabolism in men and women was early recognised; the investigation of normal metabolism is useful for a basis of comparison with the metabolism of individuals performing different amounts of work, subsisting on different diets or suffering from various diseases.

Du Bois considered body surface and age as the most accurate physiological factors to which to refer the metabolism of individuals. After the body surface has been computed by means of the height-weight formula, one can find in the table the number of calories per square meter of body surface corresponding to the particular age, and easily calculate the normal basal metabolism.

Harris and Benedict assert that the metabolism of the human body, even at rest, does not depend upon Newton's law of cooling and therefore is not proportional to the body surface. They maintain that, in predicting basal metabolism, biologically, the most rational and, practically the most satisfactory method is that secured by taking into account the body weight, stature and age of the subject. Each of these factors, they believe, has an independent influence upon metabolism. They have therefore prepared two formulæ from which to predict the daily basal heat production from body weight, stature and age.

Dreyer has objected to the introduction of the standing height as a factor in the calculation of the surface area on the ground that it is not a physiological measurement, and he regards the sitting height as a more appropriate measurement. He has evolved two formulæ based on age and weight alone.

Means and Woodwell have presented a critical analysis of the variation between, and the relative accuracy of, these three kinds of standards for estimating normal basal metabolism. After a thorough study of the merits of the three standards, they reach the conclusion that the results obtained with the three are so similar

that a subtraction of 1.8 calories from each of Du Bois' standards will render the difference between the Du Bois and the Harris-Benedict values so slight as to be almost negligible.

I have elaborated three methods of calculating the normal standard of the basal metabolism of the Japanese. These methods are based on those of Du Bois, Harris-Benedict and Dreyer as above mentioned, but the value of the heat production and the constants in the formulæ were changed in accordance with my own results.

1. With the Du Bois height-weight formula $A = W^{.425} \times H^{.125} \times 72.46$, the surface area of the body is calculated from the body weight and body height. This figure is then multiplied by that representing the basal metabolism according to age and sex, as shown in the following table. This gives the basal metabolism per hour, and multiplied by 24 gives the calories produced in 24 hours.

Age	Male	Female
20 to 30	37.83 cals.	34.34 cals.
31 to 40	37.33 »	33.84 »
41 to 50	36.83 »	33.34 »

2. Applying the following formula, the basal metabolism per day can be calculated from the body height, weight and age.

$$\text{Male} \quad h = 222.121 + 5.975s + 5.361w - 2.683a$$
$$\text{Female} \quad h = 591.620 + 2.434s + 3.815w - 1.689a$$

(h = calories per day, s = body height in cms., w = body weight in kilograms, a = age in years.)

3. Applying the following formula, the basal metabolism per day can be calculated from the body weight and age:

$$\text{Male} \quad h = \frac{\sqrt{w}}{0.1070 \times a^{0.1333}}$$

$$\text{Female} \quad h = \frac{\sqrt{w}}{0.1251 \times a^{0.1333}}$$

The above calculations are rather complicated. Therefore, I have devised a simple method of finding the basal metabolism by means of charts.

The foregoing three methods give about the same results, but each has its particular value. For instance, the third formula does not take into consideration the body height, consequently the calculations for an unusually tall person would be erroneous.

The same holds true in the case of the second formula. In this case, if body height and weight are unusual, the result is erroneous. These two formulæ could not be applied for the prediction of the basal metabolism of European and American subjects. In such cases the first formula is the best.

(2) *Application of the Normal Standard to Experimental Results.*

The normal standard of basal metabolism has been settled. I must now compare my experimental results with this normal standard. The differences between the experimental results and the standard metabolism predicted by these three methods have been calculated. The results are as follows:

Table 9. — Policemen.

Sujets Subject	Cal. (expér.) Cals. (Experimental)	Cal. I méth. Cals. I method	Diff.	%	Cal. II méth. Cals. II method	Diff.	%	Cal. III méth. Cals. III method	Diff.	%
Shibuya . . .	1403	1347	+ 56	+ 4.2	1373	+ 30	+ 2.2	1377	+ 26	+ 1.9
Ikeuchi . . .	1378	1284	+ 94	+ 7.3	1284	+ 94	+ 7.5	1234	+144	+11.7
Nagasaka . .	1617	1493	+124	+ 8.3	1475	+142	+ 9.6	1526	+ 91	+ 6.0
Hakosaki . .	1659	1534	+125	+ 8.1	1481	+177	+12.0	1506	+153	+10.2
Kobayashi .	1440	1375	+ 65	+ 4.7	1382	+ 58	+ 4.2	1383	+ 57	+ 4.1
Maniwa . . .	1564	1494	+ 10	+ 4.7	1428	+136	+ 9.5	1541	+ 23	+ 1.5
Kuboki . . .	1399	1503	—104	— 6.9	1474	— 75	— 5.1	1498	— 99	— 6.6
Watari . . .	1257	1302	— 45	— 3.5	1342	— 85	— 6.3	1305	— 48	— 3.7
Okamoto . .	1699	1608	+ 91	+ 5.7	1505	+194	+12.9	1578	+121	+ 7.7
Makino . . .	1326	1347	— 21	— 1.6	1380	— 54	— 3.9	1405	— 79	— 5.6
Moyenne . Average . .	—	—	—	+ 3.10	—	—	+ 4.26	—	—	+ 2.72
Moyenne totale Total average	—	—	—	—	—	—	—	—	—	+ 3.36

Table 10. — Teachers.

Sujets Subject	Cal. (expér.) Cals. (Experimental)	Cal. I méth. Cals. I method	Diff.	%	Cal. II méth. Cals. II method	Diff.	%	Cal. III méth. Cals. III method	Diff.	%
Sakurai . . .	1540	1473	+ 67	+ 4.6	1449	+ 91	+ 6.3	1460	+ 80	+ 5.5
Ibuka. . . .	1210	1340	—130	— 9.7	1333	—123	— 9.2	1380	—170	—12.3
Owaki . . .	1141	1299	—158	—12.2	1300	—159	—12.2	1242	—101	— 8.1
Suzuki . . .	1239	1333	— 94	— 7.1	1359	—120	— 8.8	1384	—145	—10.5
Sakurai . . .	1452	1390	+ 62	+ 4.5	1362	+ 90	+ 6.2	1348	+104	+ 7.7
Hagaki . . .	1450	1390	+ 60	+ 4.3	1341	+109	+ 7.5	1400	+ 50	+ 3.6
Isawa . . .	1220	1344	—124	— 9.2	1346	—126	— 9.4	1296	— 76	— 5.9
Adachi . . .	1438	1487	— 49	— 3.3	1446	— 8	— 0.6	1414	— 24	+ 1.7
Shibayama .	1410	1425	— 15	— 1.1	1407	+ 3	+ 0.2	1351	+ 59	+ 4.4
Nagumo . .	1379	1385	— 6	— 0.4	1384	— 5	— 0.4	1364	+ 15	+ 1.1
Ogawa . . .	1239	1384	—145	—10.5	1384	—145	—10.1	1413	—174	—12.3
Moyenne . Average . .	—	—	—	— 3.65	—	—	— 2.77	—	—	— 2.28
Moyenne totale Total average	—	—	—	—	—	—	—	—	—	— 2.90

Table 11. — Conductors and Motor-men.

Sujets Subject	Cal. (expér.) Cals. (Experimental)	Cal. I méth. Cals. I method	Diff.	%	Cal. II méth. Cals. II method	Diff.	%	Cal. III méth. Cals. III method	Diff.	%
Hayashi. . .	1397	1444	— 47	— 3.3	1400	— 3	— 0.2	1374	+ 23	+ 1.7
Nakashima .	1657	1444	+213	+14.8	1411	+246	+17.4	1470	+187	+12.7
Watanabe .	1324	1356	— 32	— 2.4	1379	— 55	— 4.0	1362	— 38	— 2.8
Aoki	1420	1421	— 1	— 0.1	1386	+ 34	+ 2.5	1380	+ 40	+ 2.9
Kanai . . .	1121	1256	—135	—10.7	1319	—198	—15.0	1298	—177	—13.6
Ohashi . . .	1545	1504	+ 41	+ 2.7	1448	+ 97	+ 6.7	1474	+ 71	+ 4.8
Hagaki . . .	1551	1567	— 16	— 1.0	1477	+ 74	+ 5.0	1561	— 10	— 0.6
Hanai . . .	1118	1179	— 61	— 5.2	1281	—163	—12.7	1193	— 75	— 6.3
Sekiguchi . .	1131	1317	—186	—14.1	1330	—199	—15.0	1277	—146	—11.4
Ogawara . .	1641	1373	+ 88	+ 6.4	1396	+ 65	+ 4.7	1385	+ 76	+ 5.5
Aotsuka. . .	1325	1418	— 93	— 6.6	1412	— 87	— 6.2	1457	—132	— 9.1
Moyenne . Average . .	—	—	—	— 1.77	—	—	— 1.53	—	—	— 1.47
Moyenne totale Total average	—	—	—	—	—	—	—	—	—	— 1.59

Table 12. — Barbers.

Sujets Subject	Cal. (expér.) Cals. (Experimental)	Cal. I méth. Cals. I method	Diff. Diff.	% %	Cal. II méth. Cals. II method	Diff. Diff.	% %	Cal. III méth. Cals. III method	Diff. Diff.	% %
Hoshino. . .	1413	1358	+ 54	+ 4.0	1306	+107	+ 8.2	1327	+ 86	+ 6.5
Ishioka . . .	1284	1347	— 63	— 4.7	1448	— 64	— 4.7	1322	— 38	— 2.9
Kato	1421	1467	— 46	— 3.1	1428	— 7	— 0.5	1319	+102	+ 7.7
Noguchi. . .	1210	1256	— 46	— 3.7	1286	— 76	— 5.9	1223	— 13	— 1.1
Suzuki . . .	1314	1335	— 21	— 1.6	1336	— 22	— 1.6	1363	— 49	— 3.6
Kasugai . . .	1275	1254	+ 21	+ 1.7	1284	— 9	— 0.7	1244	+ 31	+ 2.5
Suzuki . . .	1198	1295	— 97	— 7.5	1330	—132	— 9.9	1297	— 99	— 7.6
Nogami . . .	1345	1273	+ 72	+ 5.7	1301	+ 44	+ 3.4	1300	+ 45	+ 3.5
Kaboyashi .	1231	1321	— 90	— 6.8	1306	— 75	— 5.7	1357	— 126	— 9.3
Moyenne . Average . .	—	—	—	— 1.78	—	—	— 1.93	—	—	— 0.48
Moyenne totale Total average	—	—	—	—	—	—	—	—	—	— 1.40

Table 13. — Labourers.

Sujets Subject	Cal. (expér.) Cals. (Experimental)	Cal. I méth. Cals. I method	Diff.	%	Cal. II méth. Cals. II method	Diff.	%	Cal. III méth. Cals. III method	Diff.	%
Urano . . .	1474	1455	+ 19	+ 1.3	1429	+ 45	+ 3.1	1542	— 68	— 4.4
Watanabe .	1527	1383	+114	+10.4	1379	+148	+10.7	1423	+104	+ 7.3
Kose	1277	1263	+ 14	+ 1.1	1309	— 32	— 2.4	1279	— 2	— 0.2
Shinbo . . .	1473	1396	+ 77	+ 5.5	1371	+102	+ 7.4	1418	+ 55	+ 3.9
Koyama . .	1510	1429	+ 81	+ 5.7	1369	+141	+10.3	1345	+165	+12.3
Takatori . .	1666	1444	+222	+15.4	1427	+239	+16.7	1420	+246	+17.3
Katsura . . .	1200	1150	+ 50	+ 4.3	1233	— 33	— 2.7	1170	+ 30	+ 2.6
Ishida . . .	1574	1539	+ 35	+ 2.3	1481	+ 93	+ 6.3	1486	+ 88	+ 5.9
Moyenne . Average . .	—	—	—	+ 5.75	—	—	+ 6.18	—	—	+ 5.59
Moyenne totale Total average	—	—	—	—	—	—	—	—	—	+ 5.84

Table 14. — Factory Workmen.

Sujets Subject	Cal. (expér.) Cals. (Experimental)	Cal. I méth. Cals. I method	Diff.	%	Cal. II méth. Cals. II method	Diff.	%	Cal. III méth. Cals. III method	Diff.	%
Mori	1476	1408	+ 68	+ 4.8	1384	+ 92	+ 6.6	1333	+143	+10.7
Fukusawa .	1409	1395	+ 14	+ 1.0	1387	+ 22	+ 1.6	1389	+ 20	+ 1.4
Sato	1295	1335	— 40	— 3.0	1346	— 51	— 3.8	1384	— 88	— 6.4
Mori	1253	1455	—102	— 7.0	1423	— 70	— 4.9	1515	—162	—10.7
Ida	1451	1411	+ 40	+ 2.8	1392	+ 59	+ 4.2	1379	+ 72	+ 5.2
Kobayashi .	1292	1317	— 25	— 1.9	1344	— 52	— 3.9	1267	+ 25	+ 2.0
Okazaki . . .	1206	1305	— 99	— 7.6	1351	—145	—10.7	1331	—125	— 9.4
Ito	1363	1360	+ 3	+ 0.2	1333	+ 30	+ 2.3	1337	+ 26	+ 1.9
Kagami . .	1138	1160	— 22	— 1.0	1210	— 72	— 6.0	1069	+ 69	+ 6.5
Moyenne . Average . .	—	—	—	— 1.30	—	—	— 2.13	—	—	+ 0.13
Moyenne totale Total average	—	—	—	—	—	—	—	—	—	— 1.19

Table 15. — SCHOLARS, ETC.

Sujets Subject	Cal. (expér.) Cals. (Experimental)	Cal. I méth. Cals. I method	Diff.	%	Cal. II méth. Cals. II method	Diff.	%	Cal. III méth. Cals. III method	Diff.	%
Ito	1500	1465	+ 35	+ 2.4	1425	+ 75	+ 5.3	1397	+103	+ 7.4
Honda . . .	1514	1534	— 23	— 1.5	1457	+ 57	+ 3.9	1460	+ 54	+ 3.7
Toyama . . .	1617	1719	+ 98	+ 6.4	1447	+170	+11.7	1455	+162	+11.1
Shindo . . .	1098	1267	—169	—13.3	1300	—2.2	—15.5	1196	— 98	— 8.2
Kawakami .	1428	1392	+ 36	+ 2.6	1359	+ 69	+ 5.1	1337	+ 91	+ 6.7
Kikuchi . . .	1578	1580	— 2	— 0.1	1505	+ 73	+ 4.8	1584	— 6	— 0.3
Furumizo . .	1242	1342	—100	— 7.4	1355	—113	— 8.4	1415	—173	—12.2
Shigeta . . .	1278	1250	+ 28	+ 2.2	1300	— 31	— 2.4	1256	+ 22	+ 1.7
Takagoromo	1525	1491	+ 34	+ 2.3	1451	+ 74	+ 5.1	1405	+120	+ 8.5
Yamana . .	1357	1358	— 1	— 0.1	1364	— 7	— 0.5	1359	— 11	— 0.2
Ito	1655	1589	+ 66	+ 4.2	1486	+169	+11.3	1655	0	0
Moyenne . Average . .	—	—	—	— 0.21	—	—	— 1.86	—	—	+ 1.66
Moyenne totale Total average	—	—	—	—	—	—	—	—	—	+ 1.10

Table 16. — MERCHANTS.

Sujets Subject	Cal. (expér.) Cals. (Experimental)	Cal. I méth. Cals. I method	Diff.	%	Cal. II méth. Cals. II method	Diff.	%	Cal. III méth. Cals. III method	Diff.	%
Iwase	1109	1174	— 65	— 5.5	1261	—152	—12.1	1218	—109	— 8.9
Takahashi . .	1261	1289	— 28	— 2.2	1328	— 67	— 5.1	1303	— 42	— 3.2
Ishiyama . .	1159	1393	—234	—16.8	1324	—165	—12.5	1326	—167	—11.8
Kimura . . .	1112	1259	—147	—11.6	1320	—208	—15.7	1246	—134	—10.8
Tsutsui . . .	1332	1344	— 12	— 0.9	1358	— 26	— 1.9	1344	— 12	— 0.9
Suda	1315	1320	— 5	— 0.3	1363	— 48	— 3.6	1312	+ 3	+ 0.2
Moyenne . Average . .	—	—	—	— 6.25	—	—	— 8.48	—	—	— 5.90
Moyenne totale Total average	—	—	—	—	—	—	—	—	—	— 6.87

Table 17. — TEACHERS.

Sujets Subject	Cal. (expér.) Cals. (Experimental)	Cal. I méth. Cals. I method	Diff.	%	Cal. II méth. Cals. II method	Diff.	%	Cal. III méth. Cals. III method	Diff.	%
Ito	955	1113	—158	—14.2	1080	—125	—11.6	1057	—102	— 9.6
Abe	1051	1072	— 21	— 2.0	1054	— 3	— 0.3	1013	+ 38	+ 3.7
Ishisawa . .	990	1010	— 20	— 2.0	1047	— 57	— 5.4	1037	— 47	— 4.5
Mukai . . .	1099	1221	—122	—10.0	1122	— 23	— 2.5	1199	—100	— 8.3
Ayukai . . .	985	1145	—160	—14.0	1079	— 94	— 8.7	1103	—118	—10.7
Kobayashi .	947	1134	—187	—16.5	1077	—130	—12.1	1059	—112	—10.5
Okayama . .	1013	1108	— 95	— 8.4	1068	— 55	— 5.1	1070	— 57	— 5.3
Hayashi. . .	1183	1143	+ 40	+ 3.5	1074	+109	+10.1	1093	+ 90	+ 8.2
Kiuchi . . .	1219	1340	—121	— 9.0	1159	+ 60	+ 5.2	1264	— 45	— 3.5
Fukui. . . .	1220	1095	+125	+11.4	1070	+150	+14.0	1024	+ 96	+ 9.3
Tomita . . .	1130	1159	— 29	— 2.5	1095	+ 35	+ 3.2	1126	+ 4	+ 0.3
Nagano . . .	1049	1152	—103	— 9.1	1087	— 38	— 3.5	1136	— 87	— 7.6
Sato	971	1055	— 84	— 8.0	1063	— 92	— 8.6	1098	—127	—11.6
Saito	957	1116	—159	—14.2	1084	—127	— 2.7	1079	—122	—11.3
Onoda . . .	978	1104	—126	—11.4	1053	— 75	— 7.1	1043	— 65	— 6.2
Miyamoto . .	944	1050	—106	—10.0	1030	— 86	— 8.3	985	— 41	— 4.1
Moyenne . Average . .	—	—	—	— 7.28	—	—	— 2.71	—	—	— 4.48
Moyenne totale Total average	—	—	—	—	—	—	—	—	—	— 4.82

Table 18. — OFFICE GIRLS.

Sujets Subject	Cal. (expér.) Cals. (Experimental)	Cal. I méth. Cals. I method	Diff.	%	Cal. II méth. Cals. II method	Diff.	%	Cal. III méth. Cals. III method	Diff.	%
Ichino . . .	1268	1255	+ 13	+ 1.0	1135	+133	+11.7	1220	+ 48	+ 2.2
Wakana. . .	1341	1222	+119	+ 9.7	1128	+213	+18.8	1206	+135	+11.2
Ishitsuka . .	1024	1108	— 84	— 7.6	1081	— 56	— 5.2	1094	— 70	— 6.4
Kaida . . .	1244	1195	+ 49	+ 4.1	1108	+136	+11.3	1167	+ 77	+ 6.6
Shiota . . .	1248	1280	— 32	— 2.5	1157	+ 91	+ 7.8	1313	— 65	— 4.9
Okamura . .	1117	1106	+ 11	+ 1.0	1086	+ 31	+ 2.9	1084	+ 33	+ 3.0
Nakamura. .	1156	1069	+ 87	+ 8.1	1067	+ 89	+ 8.3	1079	+ 77	+ 7.1
Kuroki . . .	1118	1177	— 59	— 5.0	1110	+ 8	+ 0.7	1146	— 28	— 2.4
Nakakubo . .	1467	1264	+203	+16.1	1141	+326	+28.6	1245	+222	+17.8
Takeuchi . .	1152	1064	+ 88	+ 8.3	1065	+ 87	+ 8.2	1096	+ 56	+ 5.1
Matsusaki . .	1127	1028	+ 99	+ 9.6	1060	+ 67	+ 6.3	1098	+ 29	+ 2.6
Obama . . .	1052	1031	+ 21	+ 2.0	1052	0	0	1053	— 1	— 0.1
Nakasawa .	971	1097	—126	—11.5	1077	—106	— 9.8	1110	—139	—12.5
Takigawa . .	1215	1212	+ 3	+ 0.2	1108	+ 97	+ 8.7	1184	+ 31	+ 2.6
Otomo . . .	1130	1114	+ 16	+ 1.4	1088	+ 42	+ 3.9	1119	+ 11	+ 0.9
Uchiyama .	1119	1096	+ 23	+ 2.1	1072	+ 47	+ 4.4	1110	+ 9	+ 0.8
Moyenne . Average . .	—	—	—	+ 2.31	—	—	+ 6.66	—	—	+2.10
Moyenne totale Total average	—	—	—	—	—	—	—	—	—	+3.69

Table 19. — Labourers.

Sujets / Subject	Cal. (expér.) Cals. (Experimental)	Cal. I méth. Cals. I method	Diff.	%	Cal. II méth. Cals. II method	Diff.	%	Cal. III méth. Cals. III method	Diff.	%
Urabe . . .	1153	1108	+ 45	+ 4.1	1076	+ 77	+ 7.2	1129	+ 24	+ 2.1
Tatesaki . .	1110	1035	+ 75	+ 7.2	1046	+ 64	+ 6.1	1047	+ 73	+ 7.0
Sekiguchi . .	1113	1031	+ 82	+ 8.0	1038	+ 75	+ 7.2	1011	+102	+ 1.0
Komoda . .	998	1034	— 36	— 3.5	1023	— 25	— 2.4	964	+ 34	+ 3.5
Kobayashi .	975	994	— 19	— 1.9	1010	— 35	— 3.4	931	+ 44	+ 4.7
Ishikawa . .	1011	982	+ 29	— 3.0	1017	— 6	— 0.6	970	+ 41	+ 4.2
Okabe . . .	1103	1007	+ 96	+ 9.5	1027	+ 76	+ 7.4	1033	+ 70	+ 6.8
Yamada . .	953	960	— 7	— 7.3	1000	— 47	— 4.7	927	+ 26	+ 2.8
Yamada . .	1140	1014	+124	+12.2	1045	+ 95	+ 9.0	1117	+ 23	+ 2.1
Ito	1178	1101	+ 77	+ 7.0	1064	+114	+10.7	1053	+115	+11.9
Tsukada . .	1014	1007	+ 7	+ 0.7	1027	— 13	— 1.2	1028	— 14	— 1.4
Moyenne . / Average . .	—	—	—	+ 3.55	—	—	+ 3.21	—	—	+ 4.06
Moyenne totale / Total average	—	—	—	—	—	—	—	—	—	+ 3.61

Table 20. — Summarising Table.

Groupes de sujets / Group of subjects	Méthode I Method	Méthode II Method	Méthode III Method	Moyenne Average
Agents de police – Policemen	+ 3.10	+ 4.26	+ 2.72	+ 3.36%
Instituteurs – Teachers. . .	- 3.65	— 2.77	— 2.28	— 2.90%
Receveurs – Conductors . .	— 1.77	— 1.53	— 1.47	— 1.59%
Coiffeurs – Barbers	— 1.78	— 1.93	— 0.48	— 1.40%
Manœuvres – Labourers . .	+ 5.75	+ 6.18	+ 5.59	+ 5.84%
Ouvriers d'usine – Factory workmen.	— 1.30	— 2.13	+ 0.13	— 1.19%
Intellectuels – Scholars, etc.	— 0.21	+ 1.86	+ 1.66	+ 1.10%
Négociants – Merchants . .	— 6.25	— 8.48	— 5.90	— 6.87%
Sexe féminin – Female				
Institutrices – Teachers . .	— 7.28	— 2.71	— 4.48	— 4.82%
Employées de bureau – Office girls	+ 2.31	+ 6.66	+ 2.10	+ 3.69%
Manœuvres – Labourers . .	+ 3.55	+ 3.21	+ 4.06	+ 3.61%

As is shown in Table 20, these three prediction methods gave almost the same results. The variation of the metabolism in various groups ranges from + 5.84 to — 6.87 per cent in males and from + 3.69 to — 4.82 per cent in females. Considering the divergence of the metabolism of particular individuals from the normal standard, one can conclude the following:

1. The average metabolism is higher in persons of larger body size, *e.g.*, larger body weight or body height.
2. The metabolism is higher in younger persons.
3. The average metabolism is higher in the group of labourers and lower in the group of teachers and merchants.

(3) *The Difference in the Basal Metabolism of Japanese and Americans.*

There are differences in the dietaries, muscular work, climate and mode of living of the races. Is there any difference in the basal metabolism between the Japanese and European or American people ? To elucidate this point, I may quote the following four series of experimental results obtained with the universal respiration apparatus or the respiration calorimeter:

1. Results of Palmar, Means and Gamble on eight normal men.
2. Results of Carpenter, Emmes, Hendry and Roth on 31 normal men.
3. Results of Palmar, Means and Gamble on seven normal women.
4. Results of Johnson, Corson and Roth on 20 normal women.

The difference between the figures obtained with American subjects and those predicted by the first method in the case of Japanese subjects have been calculated. The results are as follows:

Table 21. — Results of Palmar, Means and Gamble.

Sujets Subject	Age	Poids Weight	Taille Height	Superficie Surface area	Cal. Cals.	Cal. méth. I Cals. I meth.	Diff.	%
W. W. P.	32	93.9	187	2.20	2004	1982	+ 22	+ 1.1
H. L. H.	27	62.0	172	1.73	1574	1567	+ 7	+ 0.4
W. S. W.	25	73.8	177	1.91	1660	1734	— 74	— 4.2
L. W. H.	25	68.4	169	1.79	1671	1625	+ 46	+ 2.8
P. H. P.	27	77.2	172	1.91	1620	1729	— 109	— 6.3
J. H. M.	29	70.7	175	1.85	1599	1671	— 72	— 4.3
J. L. G.	30	68.1	181	1.87	1679	1089	— 10	— 0.6
L. H. N.	31	58.1	169	1.67	1452	1504	— 52	— 3.4
Moyenne Average	—	—	—	—	—	—	—	—1.81%

Table 22. — Results of Carpenter, Emmes, Hendry and Roth.

Sujet Subject	Age	Poids Weight	Taille Height	Superficie Surface area	Cal. Cals.	Cal. méth. I Cals. I meth.	Diff.	%
W. G. S.	19	63.5	171	1.75	1704	1601	+ 103	+ 6.4
E. R. K.	20	69.0	168	1.78	1812	1629	+ 183	+11.2
A. S. P.	21	69.3	169	1.80	1733	1643	+ 90	+ 5.4
J. L. G.	21	65.5	163	1.71	1600	1621	— 21	— 1.3
G. C. G.	22	71.3	171	1.83	1874	1670	+ 204	+12.2
R. T. V.	22	65.8	175	1.80	1610	1643	— 33	— 2.0
H. H. H.	22	71.5	173	1.84	1793	1679	+ 114	+ 6.8
J. F. T.	22	63.8	188	1.87	1750	1707	+ 43	+ 2.5
D. G. H.	22	52.1	176	1.63	1549	1488	+ 61	+ 4.1
R. K. B.	22	65.8	179	1.83	1694	1670	+ 24	+ 1.4
C. A. C.	22	64.9	180	1.83	1656	1670	— 14	— 0.8
A. C. B.	22	77.6	175	1.93	1533	1761	—227	—12.8
H. A. M.	23	63.5	174	1.76	1702	1602	+ 100	+ 6.2
S. N. G.	23	60.8	178	1.76	1827	1602	+ 225	+14.0
W. J. S.	23	56.5	172	1.67	1330	1520	—190	—12.5
H. O.	23	67.2	172	1.79	1628	1615	+ 13	+ 0.8
C. F. M.	23	51.1	161	1.52	1258	1384	—126	— 9.1
O. A. G.	24	66.8	166	1.74	1788	1584	+ 204	+12.9
T. H. N.	24	69.1	190	1.95	1868	1775	+ 93	+ 5.2
A. G. N.	24	59.9	172	1.71	1600	1557	+ 43	+ 2.7
F. S.	24	57.4	172	1.68	1515	1529	— 14	— 0.9
W. F. M.	24	76.1	181	1.96	1863	1784	+ 79	+ 4.4
C. S. B.	24	61.4	174	1.74	1632	1584	+ 48	+ 3.0
L. J. T.	25	57.5	176	1.73	1471	1471	—100	— 6.3
L. F. F.	25	57.5	167	1.64	1606	1489	—117	— 7.8
J. A. C.	25	59.6	177	1.74	1663	1580	+ 83	+ 5.2
H. B.	25	64.6	166	1.72	1482	1562	— 80	— 5.1
G. A. B.	26	61.8	167	1.70	1493	1543	— 50	— 3.2
K. B. C.	26	79.8	177	1.98	1759	1798	— 39	— 2.1
K. G. M.	32	68.8	171	1.80	1889	1621	+ 268	+16.5
R. W. P.	44	64.3	170	1.75	1572	1551	+ 20	+ 1.3
Moyenne Average	—	—	—	—	—	—	—	2.38

Table 23. — Results of Palmar, Means and Gamble.

Sujet Subject	Age	Poids Weight	Taille Height	Superficie Surface area	Cal. Cals.	Cal. méth. I Cals. I meth.	Diff.	%
M. A. H.	21	57.9	157	1.57	1434	1301	+ 133	+10.2
R. R.	24	20.9	169	1.81	1648	1496	+ 152	+10.1
H.	22	48.1	155	1.44	1143	1194	— 51	— 4.3
D. L.	21	76.0	168	1.86	1497	1542	— 45	— 2.9
F. M. R.	20	77.7	166	1.85	1635	1538	+ 97	+ 6.5
L. F. W.	21	79.8	170	1.92	1480	1591	— 111	— 7.0
R. Rob.	23	67.5	170	1.78	1444	1471	— 27	— 1.8
Moyenne Average	—	—	—	—	—	—	—	+ 1.54

Table 24. — Results of Johnson, Corson and Roth.

Sujets Subject	Age	Poids Weight	Taille Height	Superficie Surface area	Cal. Cals.	Cal. méth. I Cals. I meth.	Diff.	%
M.	24	56.6	160	1.58	1302	1306	— 4	— 3.1
G. B.	44	82.6	176	1.99	1383	1597	— 214	—13.4
W.	44	72.0	164	1.78	1418	1429	— 11	— 0.7
M. H.	34	70.2	160	1.74	1494	1417	+ 77	+ 5.4
O. C.	35	66.8	163	1.72	1579	1407	+ 72	+ 5.1
E. R.	22	62.7	169	1.72	1694	1426	+268	+18.6
W.	38	61.6	171	1.72	1341	1393	— 52	— 3.7
A. N. D.	41	60.7	101	1.64	1250	1320	— 70	— 5.3
M. C.	45	60.1	163	1.65	1608	1320	+ 288	+21.7
M. F.	26	59.5	156	1.68	1640	1385	+ 255	+18.4
Ma H.	20	54.5	162	1.57	1418	1306	+ 112	+ 8.5
M.	37	53.8	169	1.61	1203	1304	— 101	— 7.7
A. R. K.	25	53.5	156	1.52	1362	1253	+ 109	+ 8.7
A. E. M.	22	52.5	158	1.52	1130	1260	— 130	—10.3
L. M.	32	50.0	157	1.48	1390	1209	+ 181	+14.9
H. W.	24	49.1	160	1.49	1153	1231	— 78	— 6.3
M. M. C.	26	48.9	157	1.47	1287	1212	+ 75	+ 6.1
E. B. X.	26	44.2	159	1.42	1292	1140	+ 122	+10.4
M. M.	19	43.9	152	1.37	1143	1139	+ 4	+ 0.3
M. F.	22	41.3	157	1.36	1073	1127	— 54	— 4.8
Moyenne Average	—	—	—	—	—	—	—	+ 3.14

The differences are as follows:

	%
1.	—1.81
2.	—2.38
3.	—1.54
4.	—3.14

The difference is relatively small and varies from + 3.14 to — 1.81 per cent. One can say that the metabolism of the Japanese and the Americans is essentially the same.

7. Summary.

The basal metabolism of 120 normal men and women was studied with the respiration apparatus for clinical use. The experimental results were treated with biometric formulæ, and the average mean, the standard deviation, the variation coefficient and the correlation coefficient were determined. The results were also studied by means of graphs.

The metabolism was found to be proportional to the body height, body weight and body surface area of the subjects, but the body surface area was the most important factor. The correlation coefficient between the body surface area and the metabolism was 0.8628 in men and 0.5674 in women. The basal metabolism per square meter of body surface per hour was 37.33 calories in men and 33.84 calories in women.

The age had some influence on the basal metabolism. In the adult age of 20 to 50 years there was a correlation coefficient of — 0.0537 in men and —0.4693 in women.

The basal metabolism of men was higher than that of women. The difference between the daily heat production of men and women amounted to 22 per cent; the difference per body weight unit was 6 per cent and per body surface unit 9 per cent. Comparing the metabolism of women with the predicted metabolism for men, we found a difference of 11 per cent.

The basal metabolism varied considerably from individual to individual, but it was almost constant in the same individual.

To predict the basal metabolism of normal Japanese men and women I have devised the following three methods based on the Du Bois, Harris-Benedict, and Dreyer methods.

1. By means of the Du Bois height-weight formula $A = W^{.425} \times H^{.725} \times 72.46$, the body surface area is computed. The normal basal metabolism per square meter per hour is found in the following table:

Age	Male	Female
20 to 30	37.83	34.34
31 to 40	37.33	33.84
41 to 50	36.83	33.34

2. By means of the following formulæ, the basal metabolism per 24 hours can be calculated from the body height, weight and age:

Male . . . . $h = 222.121 + 5.975s + 5.361\ w - 2.683a$
Female . . . $h = 591.620 + 2.433s + 3.815\ w - 1.689a$

3. By means of the following formulæ, the basal metabolism per 24 hours can be calculated from the body weight and age:

$$\text{Male} \quad . \quad . \quad . \quad . \quad h = \frac{\sqrt{w}}{0.1070 \times a^{0.1333}}$$

$$\text{Female} \quad . \quad . \quad . \quad h = \frac{\sqrt{w}}{0.1251 \times a^{0.1333}}$$

These three methods give about the same results when applied to the normal Japanese man and woman.

Comparing the basal metabolism of the various groups of policemen, teachers, conductors, motor-men, barbers, labourers, scholars, factory workmen, merchants, office girls and women labourers, the average variation was from + 5.84 to — 6.84 per cent. It should be noticed that the basal metabolism is relatively higher in subjects of larger body size, in younger persons and in labourers.

The basal metabolism of American subjects is essentially the same as that of the Japanese.

2.

THE BASAL METABOLISM OF COMMON LABOURERS.

By Hideo Takahira, Sadayoshi Kitagawa, Eiichi Ishibashi, and Seizo Kayano.

(From the Imperial State Institute for Nutrition, Tokyo.)

In his report on " The Basal Metabolism of Normal Men and Women ", Takahira published his experimental results concerning the basal metabolism of 120 adult Japanese men and women. The experimental subjects varied in regard to their body size, age, profession and habits of life, and accordingly the basal metabolism varied considerably from individual to individual. It was noticed that the average basal metabolism in the group of labourers was higher than in the groups of merchants and teachers, engaged chiefly in mental work. This relation was the same in the case of the female subjects. It was a very interesting result, but the experimental data were too scanty to enable a definite conclusion to be drawn from them.

In 1923, the Social Bureau of the Tokyo City Office placed at our disposal 50 common labourers as experimental subjects, and thus we were able to determine the basal metabolism of exclusively physical labourers. Of 50 subjects, 30 were male and 20 female.

By " common labourers " are meant physical labourers without fixed jobs, usually working out of doors. The male subjects were rice polishers of the Army Commissary Department, labourers at sewer works, stone-cutters, coal-carriers, brick workers and jinrikisha men. The female subjects were working at sewing, straw cutting, and cooking in the Army Commissary Department. The ages of the subjects varied from 20 to 50 years.

The subjects were studied with the respiration apparatus for clinical use, the experimental procedure being the same as in the previous report. The experiments extended from February to April 1923. The body surface area was calculated from our new height-weight formula $A = W^{\cdot 427} \times H^{\cdot 718} \times 74.49$. The experimental results were as follows:

Table 1. — Basal Metabolism of Male Labourers.

Sujets Subject	Date de l'observation Day of observation	Age	Poids Body weight	Taille Body height	Superficie du corps Body surface	Consommation d'oxygène p. heure Oxygen consump. per hour	Production de CO^2 par heure Carbon dioxide Production p. hour	R. Q.	Elimination de N dans l'urine par heure Nitrogen excretion in urine per hour	Production de chaleur par heure Heat production per hour	Production de chaleur p. 24 h. Heat production per 24 hours	Production de chaleur p. kg. en 24 h. Heat per kilo per 24 hours	Production de chaleur p. m^2 et p. h. Heat per sq. m. per hour	Pouls Pulse rate	Respiration Respiration rate
		Yrs.	Kilos	cms.	sq. m.	l.	l.		gm.	cals.	cals.	cals.	cals.		
T. Ozaki	Apr. 21 Avril	20	57.3	161.2	1.61	15.07	11.35	0.75	0.4887	70.19	1684	29.4	43.59	40	15
Y. Naruse	» 16 »	22	57.0	160.2	1.60	13.41	11.70	0.87	0.5784	63.79	1531	26.9	39.87	59	14
M. Hatashima	» 24 »	22	56.5	155.0	1.56	13.85	11.63	0.84	0.5054	65.74	1578	27.9	42.14	42	15
S. Toda	» 23 »	23	62.2	155.3	1.63	13.03	11.29	0.87	0.4954	62.44	1499	24.1	38.31	47	14
K. Sato	» 19 »	23	60.5	164.7	1.68	14.63	13.12	0.90	0.4198	70.58	1694	28.0	42.01	57	17
M. Daito	» 20 »	23	54.7	153.0	1.53	13.53	10.64	0.79	0.4205	63.69	1528	24.9	41.62	52	16
T. Muto	» 13 »	29	60.6	169.8	1.71	13.87	12.03	0.87	0.5198	66.08	1586	26.2	38.64	58	13
H Yanagisawa	Mar. 21 Mars	35	54.7	164.5	1.60	13.72	11.76	0.86	0.3760	65.65	1576	28.8	41.03	65	19
T. Tamura	Apr. 28 Avril	39	69.4	163.0	1.76	14.48	10.96	0.76	0.3567	67.68	1624	23.3	38.45	56	15
T. Akiyama	» 14 »	20	49.0	158.0	1.49	13.65	11.11	0.81	0.3244	64.22	1541	31.4	43.10	53	12
K. Nishimura	» 7 »	22	49 2	155.0	1.50	13.51	12.70	0.4	0.4504	65.98	1584	32.2	43.98	54	15
M. Higashi	» 10 »	24	53.1	148.0	1.50	12.08	11.36	0 94	0.3360	59.03	1417	26.7	39.36	60	16
H. Ono	Mar. 20 Mars	25	49.3	159.4	1 51	11.07	10.30	0 93	0.3163	53.92	1294	26.2	35.71	45	16
M. Hatanaka	» 27 »	26	49.6	159 5	1.50	11.51	20.68	0.92	0. 653	55.91	1341	27.1	37.27	58	17
Y. Nakao	Apr. 25 Avril	28	56.6	167.9	1.65	13.98	10.86	0.78	0.3956	65.69	1577	27.8	39.77	53	15
Y. Ki	Mar. 26 Mars	31	48.4	156.6	1. 7	12.93	10.47	0.81	0.3776	61.22	1469	30.4	41.65	58	18
F. Nakasone	Apr. 26 Avril	32	47.2	145.5	1.38	12.35	9.42	0.76	0.3871	57.82	1388	29.4	41.90	47	16
T. Taguchi	May 3 Mai	38	56.7	158.0	1.58	12.76	11.84	0 93	0.4200	62.00	1488	26.2	39.24	65	22
J. Nagai	Mar. 18 Mars	40	52.0	160.3	1.54	12.56	10.04	0.80	0.4597	58.92	1414	27.2	38.26	54	16
H. Yoshida	Apr. 27 Avril	40	47.2	151.0	1.35	11.68	8.76	0.75	0.4507	54.28	1303	27.6	40.21	42	16
N. Taguchi	» 12 »	42	51.4	154.4	1 49	13.54	10.14	0.75	0.4105	62.83	1508	29.3	42.37	51	17
S. Fujino	Mar. 19 Mars	44	47.6	154.0	1.44	11.66	10.04	0.86	0.5788	55.41	1330	27.9	38.48	58	15
S. Mitsumura	» 17 »	46	53.6	158.0	1.55	13.63	10.69	0.78	0.3832	64.12	1539	28.8	41.17	60	17
E. Wada	Apr. 11 Avril	46	46.8	160.0	1.47	12.66	9.72	0.77	0.3076	59.52	1428	30.5	40.49	59	16
M. Kanayama	Mar. 16 Mars	48	49.7	150.5	1.45	11.03	10.27	0.93	0.2426	54.05	1297	26.1	37.28	59	16
K. Horiuchi	May 2 Mai	49	51.4	165.0	1.60	14.00	11.82	0.84	0.4910	67.87	1639	30.1	42.42	57	18
D. Suga	Apr. 18 Avril	21	44.1	161.2	1.44	12.74	11.54	0.91	0.4523	61.55	1477	33.5	42.74	96	15
S. Nihira	Mar. 23 Mars	39	47.3	155.0	1.45	11.69	9.63	0.90	0.3428	51.81	1243	26.3	35.73	40	15
B. Adachi	» 24 »	38	44.6	152.0	1.39	10.69	10.88	0.93	0.4679	56.70	1360	30.5	40.79	64	16
D. Tsukada	» 15 »	42	46.2	150.0	1.40	11.47	9.84	0.86	0.3415	54.88	1316	28.5	39.20	76	18
Moyenne Average		32.5	52.46	157.9	1.53	12.89	10.89	0.85	0.4164	61.45	1475	28.3	40.23	55	16

Table 2. — Basal Metabolism of Female Labourers.

Sujets Subject	Date de l'observation Day of observation	Age An. Yrs.	Poids Body weight kilos	Taille Body height cms.	Superficie du corps Body surface m^2 sq. m.	Consommation d'oxygène p. heure Oxygen consump. per hour l.	Production de CO^2 par heure Carbon dioxide production p. hour l.	R. Q.	Elimination de N. dans l'urine p. heure Nitrogen excretion in urine per hour gm.	Production de chaleur par heure Heat production per hour cals.	Production de chaleur p. 24 h. Heat production per 24 hours cals.	Production de chaleur p. kg. en 24 h. Heat per kilo per 24 hours cals.	Production de chaleur p. m^2 et p. h. Heat per sq. m. per hour cals.	Pouls Pulse rate	Respiration Respiration rate
T. Yoshida	Feb. 28 Févr.	27	50.2	145.0	1.41	10.33	9.33	0.90	0.1453	50.61	1215	24.2	35.89	59	10
I. Okawa	» 12 »	27	47.2	135.0	1.31	10.36	9.02	0.87	0.2567	49.74	1194	25.3	37.97	52	13
K. Hayakawa . . .	Mar. 1 Mars	34	62.4	154.0	1.62	13.79	10.86	0.79	0.2625	65.00	1560	25.0	40.12	66	19
S. Otaki.	Feb. 22 Févr.	43	52.9	148.0	1.47	12.22	10.08	0.82	0.2312	58.27	1390	26.5	39.64	77	20
H. Taguchi	» 24 »	43	50.0	151.0	1.46	9.18	7.92	0.86	0.2790	43.86	1053	21.1	30.04	49	15
J. Furuyama . . .	» 9 »	48	47.0	138.0	1.33	10.19	8. 6	0.85	0.2972	48.40	1169	24.8	36.62	55	17
K. Yanagihara. . .	» 20 »	20	43.5	142.2	1.31	9.54	9.07	0.95	0.4404	46.23	1110	25.5	35.29	69	18
T. Mase.	» 16 »	26	44.8	148.5	1.37	11.42	9.88	0.87	0.2828	54.77	1315	29.3	39.98	68	17
S. Ishiyama	» 27 »	28	38.6	143.0	1.25	10.42	8.39	0.81	0.1392	49.49	1188	30.8	39.59	62	14
H. Shimizu	» 7 »	29	42.8	148.5	1.34	8.67	8.36	0.96	0.3425	42.50	1020	23.9	31.71	59	15
K. Yamasaki . . .	Mar. 14 Mars	30	47.3	147.5	1.39	10.70	8.48	0.79	0.2924	50.04	1201	25.4	35.99	59	17
C. Sakai	» 13 »	37	41.6	151.0	1.34	9.64	3.68	0.90	0.4008	46.40	1114	26.8	34.69	60	10
T. Sugiura	» 5 »	40	43.1	136.9	1.27	10.18	9.16	0.90	0.2700	49.66	1192	27.7	39.11	61	13
O. Yamada	» 9 »	41	44.2	146.0	1.34	10.23	8.57	0.84	0.2015	49.12	1179	26.7	36.65	61	19
H. Hasegawa . . .	Feb. 21 Févr.	44	39.6	142.2	1.26	9.69	8.24	0.85	0.2627	46.36	1113	28.1	36.80	64	12
K. Ishii.	» 10 »	45	46.3	141.8	1.34	10.69	8.49	0.78	0.3612	50.31	1308	28.2	37.55	64	19
Y. Shiota	Mar. 10 Mars	46	38.7	139.0	1.23	8.57	6.94	0.81	0.3453	40.24	966	25.0	32.71	71	13
T. Suzuki	Feb. 13 Févr.	47	39.5	139.2	1.24	9.59	8.70	0.91	0.2783	46.47	1115	28.3	37.48	67	16
S. Takakura. . . .	» 23 »	48	44.9	149.5	1.38	10.15	7.71	0.75	0.4652	47.05	1029	22.9	34.09	82	20
M. Itakura	» 8 »	47	37.8	135.4	1.16	9.19	7.78	0.85	0.2941	43.72	1049	27.8	36.74	48	17
Moyenne Average . .		37.5	43.1	143.6	1.34	10.24	8.72	0.85	0.2924	48.93	1174	26.2	36.43	63	16

The average measurements of the 30 male subjects were 157.9 cms. body height, 52.46 kgms. body weight, 1.53 sq. m. body surface, and the average age was 32.5 years. The average basal heat production was 1,475 calories; the average respiratory quotient was 0.85, the average pulse rate was 55 and the respiration rate was 16.

The average measurements of the 20 female subjects were 143.6 cms. body height, 43.12 kgms. body weight, 1.34 sq. m. body surface, and the average age was 37.5 years. There was an average heat production of 1,174 calories; the average respiratory quotient was 0.85, the average pulse rate was 63 and the respiration rate was 16.

Comparing these results with Takahira's results obtained with 120 normal men and women, we found no significant difference in the average value of the physical characters of the subject, nor in the respiratory quotient, the pulse rate, nor in the respiration rate. There was, however, a slight difference in the basal metabolism in the two experiments.

The basal metabolism of common labourers per square meter per hour in men averaged 40.23 calories, which was higher than the normal average of 37.33 by 7.21 per cent. The basal metabolism in women averaged 36.43 calories, which was also higher than the normal average of 33.84 calories by 7.11 per cent. This relation is charted in Charts 1 and 2.

For this comparison we calculated the basal metabolism by the three prediction methods mentioned in the previous report.

[*See Table 3 and Charts Nos. 1 and 2 on pages 41 and 42.*]

The results of the three calculations are as follows:

	First method	Second method	Third Method	Average
Male	+ 7.61 %	+ 8.07 %	+ 9.02 %	+ 8.23 %
Female	+ 7.49 %	+ 11.53 %	+ 11.42 %	+ 10.15 %

The basal metabolism of common labourers as compared with the normal standard is higher in males by 8.23 per cent, and in females by 10.15 per cent.

The reason for this difference is that, in physical labour, the metabolism is increased and the after-effect of daily physical work is continued throughout the experimental period. In order to find the true minimal value of the basal metabolism, the determination should be made after many days of fasting and muscular repose.

Benedict, Emmes, Roth and Smith studied the basal metabolism of athletes and men of sedentary life, and found that in athletes the metabolism was 7 per cent higher than in men of less active life. This result is quite in accordance with our own.

It is necessary to bear in mind that, besides the body height, body weight, body surface area, age and sex, there is another important factor influencing the basal metabolism — that is, the profession or mode of living of the subjects, particularly as regards their muscular activity.

Chart 1. — Basal Metabolism of Male Labourers.

Each dot represents individual values, the straight line shows the normal basal metabolic rate.

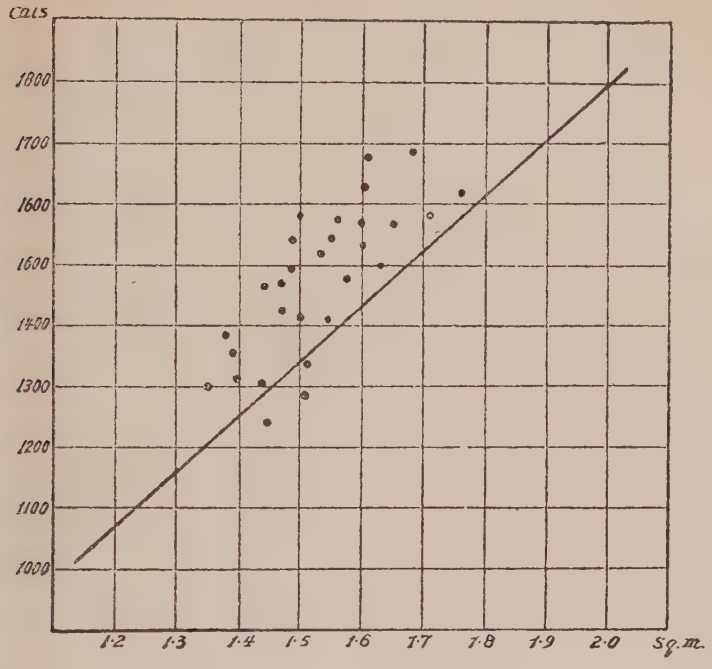


Chart 2. — Basal Metabolism of Female Labourers.

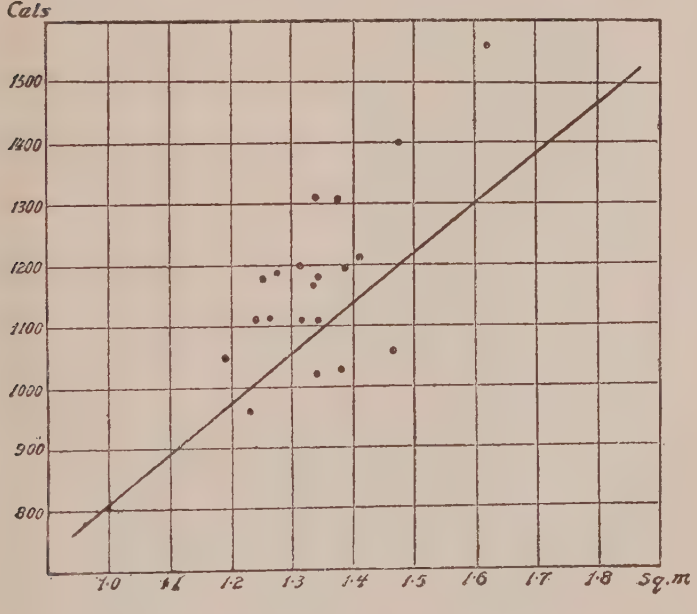


Table 3. — Comparison of Basal Metabolism of Labourers with the Predicted Normal Value.

Sujets Subject	Méth. I First Method	Méth. II Second Method	Méth. III Third Method
T. Ozaki	+ 14.3	+ 17.0	+ 12.2
Y. Naruse	+ 4.9	+ 7.4	+ 3.6
M. Hatashima	+ 10.8	+ 13.4	+ 7.1
S. Tada	+ 10.1	+ 1.0	— 2.5
K. Sato	+ 10.8	+ 15.3	+ 12.0
M. Daido	+ 9.7	+ 11.7	+ 6.7
T. Muto	+ 2.7	+ 6.9	+ 8.0
H. Yanagisawa	+ 9.9	+ 12.3	+ 13.2
T. Tamura	+ 3.6	+ 10.9	+ 7.5
T. Akiyama	+ 13.0	+ 12.1	+ 11.0
K. Nishimura	+ 15.7	+ 17.1	+ 15.5
M. Higashi	+ 3.7	+ 6.9	+ 0.6
H. Ono	— 5.6	— 5.7	— 4.2
M. Hatanaka	— 1.6	— 2.3	— 0.5
Y. Nakao	+ 5.6	+ 8.5	+ 10.6
Y. Ki	+ 11.0	+ 10.1	+ 12.9
F. Nakasone	+ 11.7	+ 10.3	+ 8.5
T. Taguchi	+ 5.4	+ 8.8	+ 8.6
J. Nagai	+ 3.1	+ 4.7	+ 8.5
H. Yoshida	+ 8.3	+ 2.6	+ 4.9
N. Taguchi	+ 13.9	+ 15.3	+ 17.2
S. Fujino	+ 4.2	+ 4.0	+ 8.0
S. Mitsumura	+ 12.3	+ 15.7	+ 18.5
E. Wada	+ 9.9	+ 9.3	+ 17.6
M. Kanayama	+ 1.5	+ 3.0	+ 4.3
K. Horiuchi	+ 15.8	+ 9.8	+ 29.1
D. Suga	+ 12.4	+ 8.2	+ 12.9
S. Nihira	— 4.1	— 4.6	+ 1.0
B. Adachi	+ 9.5	+ 7.3	+ 11.9
D. Tsukada	+ 5.8	+ 5.0	+ 7.8
Moyenne Average	+ 7.61	+ 8.07	+ 9.02

Sujets Subject	Méth. I First Method	Méth. II Second Method	Méth. III Third Method
T. Yoshida	+ 4.8	+ 10.5	+ 5.2
I. Okawa	+ 10.9	+ 13.2	+ 6.6
K. Hayakawa	+ 18.2	+ 36.0	+ 25.0
S. Otaki	+ 18.6	+ 29.4	+ 25.7
H. Taguchi	— 10.2	— 2.2	— 2.8
J. Furuyama	+ 10.2	+ 13.9	+ 13.1
K. Yanagihara	+ 1.0	+ 3.7	+ 0.7
T. Mase	+ 16.5	+ 21.8	+ 14.3
S. Ishiyama	+ 15.7	+ 14.2	+ 18.0
H. Shimizu	— 7.1	— 4.4	— 3.3
K. Yamasaki	+ 5.5	+ 11.2	+ 8.1
C. Sakai	+ 2.7	+ 5.6	+ 10.5
T. Sugiura	+ 16.3	+ 16.6	+ 17.4
O. Yamada	+ 9.3	+ 12.7	+ 15.1
H. Hasegawa	+ 10.1	+ 9.7	+ 15.8
K. Ishii	+ 12.4	+ 25.9	+ 26.0
Y. Shiota	— 1.8	— 3.4	+ 2.4
T. Suzuki	+ 12.7	+ 11.3	+ 17.2
S. Takakura	— 6.5	— 1.6	+ 1.9
M. Itakura	+ 10.5	+ 6.4	+ 12.8
Moyenne Average	+ 7.49	+ 11.53	+ 11.42

ON THE ENERGY EXCHANGE IN THE VARIOUS INDUSTRIAL OCCUPATIONS

By Kōtaro Takahashi

(From the Laboratory of Industrial Efficiency, the Department of Commerce and Industry).

The author has studied the energy exchange in men engaged in various industrial occupations. The experiments were carried out by means of a mouth-piece, nose clip, Douglas bag, and Haldane gas analysis apparatus. The principal findings were as follows:

1. Considering the energy value in standing as 100, the energy exchange in the various occupations was as in Table 1 (the subjects used comprised 45 men and 20 women).

Table 1. — Energy Value in Various Occupations

Kind of Labours	Standing (men)	Watch-making	Calculating with an Abacus	Lathe Work	Finishing Work	Furnace Work	Hand-smith Work	Firemen's Work	Standing (women)	Reeling Work	Twist Work	Investigating Work	Patch Work
Subjects used in experiment	31	5	9	13	6	3	4	5	13	7	5	4	4
Oxygen consumption per hour (l).	10.91	9.90	11.23	20.86	36.01	43.70	51.17	53.16	9.06	10.00	14.11	14.50	16.10
Energy Value	100	91	103	191	330	400	469	487	100	110	156	160	178

2. The oxygen consumption immediately after the work is finished is considerably greater than during the period before the work was begun. This increase is proportional to the severity of the work. The increased quantity of oxygen consumed must, of course, be added to the oxygen consumed during work.

Table 2. — Oxygen Consumption before, during and after Work (Silk-spinning Work).

Subject	Oxygen consumption per min. (c.c.)				Oxygen consumption (comparison)			
	Before work	During work	Directly after work	1 min. after work	Before work	During work	Directly after work	1 min. after work
Y. T.	201.1	783.0	381.6	245.2	100	389	190	126
I. O.	210.8	641.2	341.5	236.2	100	304	162	112

Table 3. — Oxygen Consumption before, during and after Walking and Running (c.c. per min.).

Subject	Before walking	During walking	After walking	Distance (m.)	During running	After running	Distance (m.)
S. T.	272.3	834.9	364.2	60.3	1053.8	451.6	79.2
K. T.	226.6	769.1	370.3	78.0	1186.3	436.9	120.0
K. T.	243.6	722.2	214.4	75.9	1450.4	911.0	153.4

3. The oxygen consumption varies at different periods during the day's work. Gas analysis experiments were carried out at 10 a.m., 11.30 a.m., 1 p.m., 2.30 p.m., and 4 p.m.; 48 experiments were undertaken as follows:

20 experiments type 1
12 » » 2
6 » » 3
6 » » 4
4 » » 5

Chart 1. — Oxygen Consumption before, during and after Work.

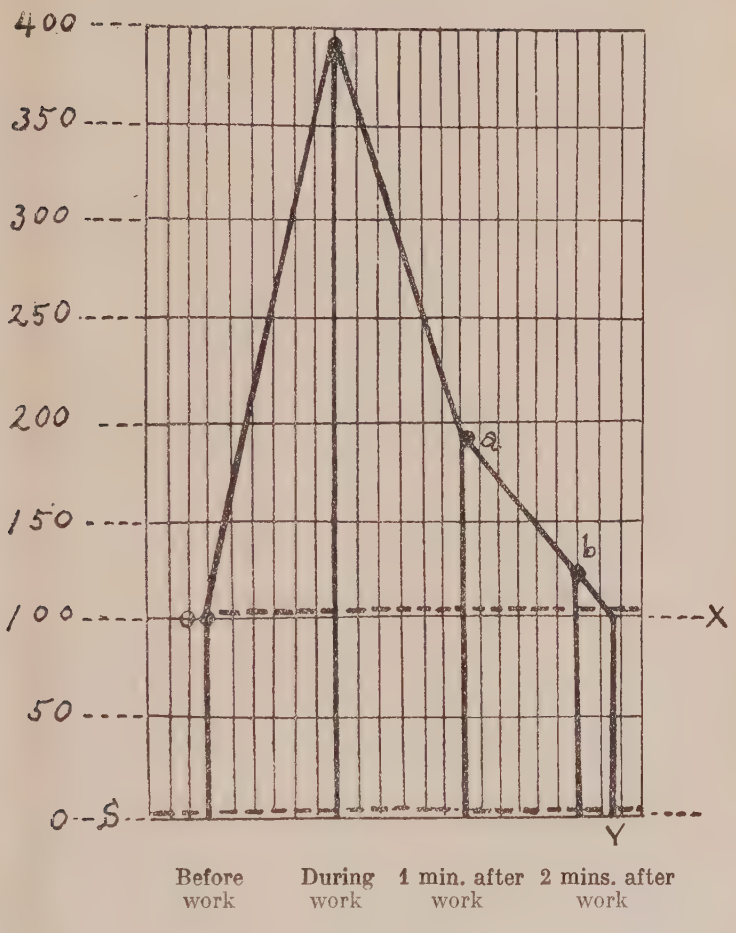


Chart 2. — Type 1, No. 1.

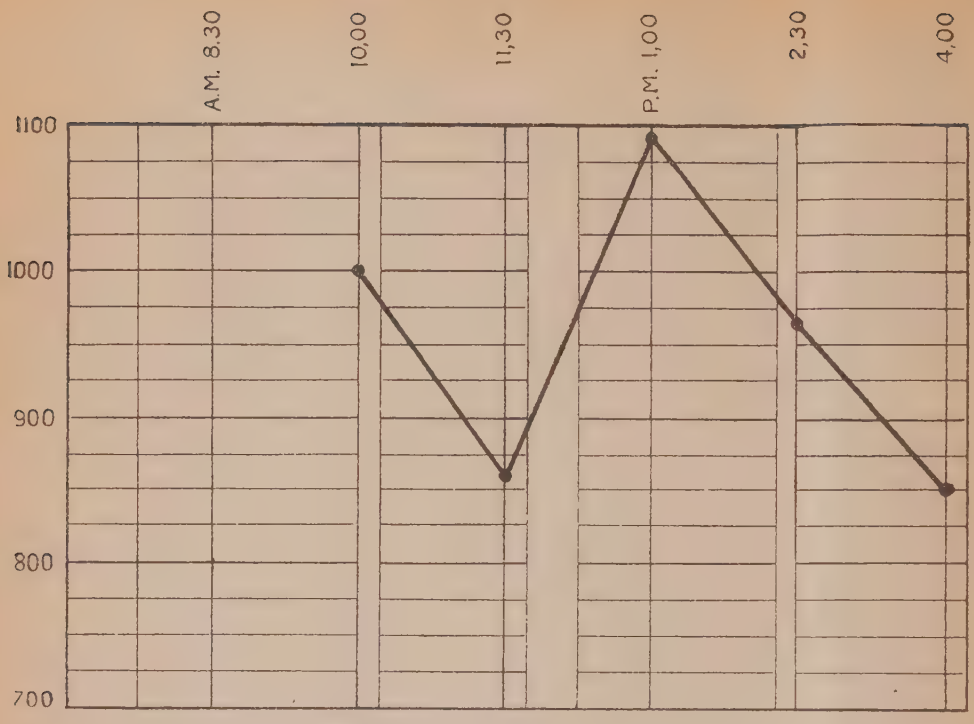


Chart 3. — Type 1, No. 2.

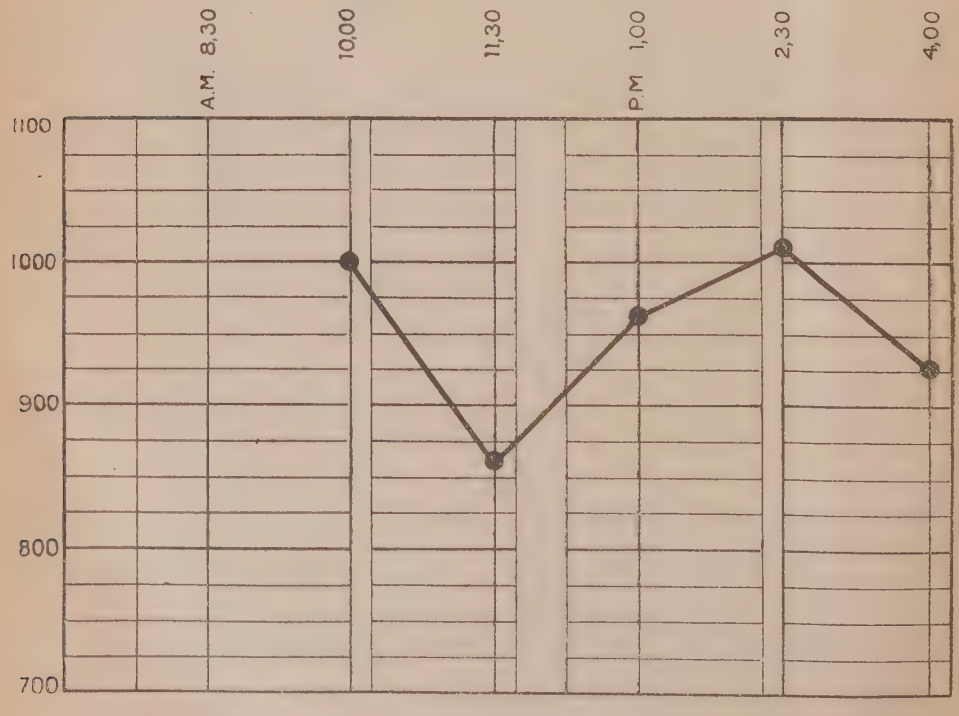


Chart 4. — Type 2.

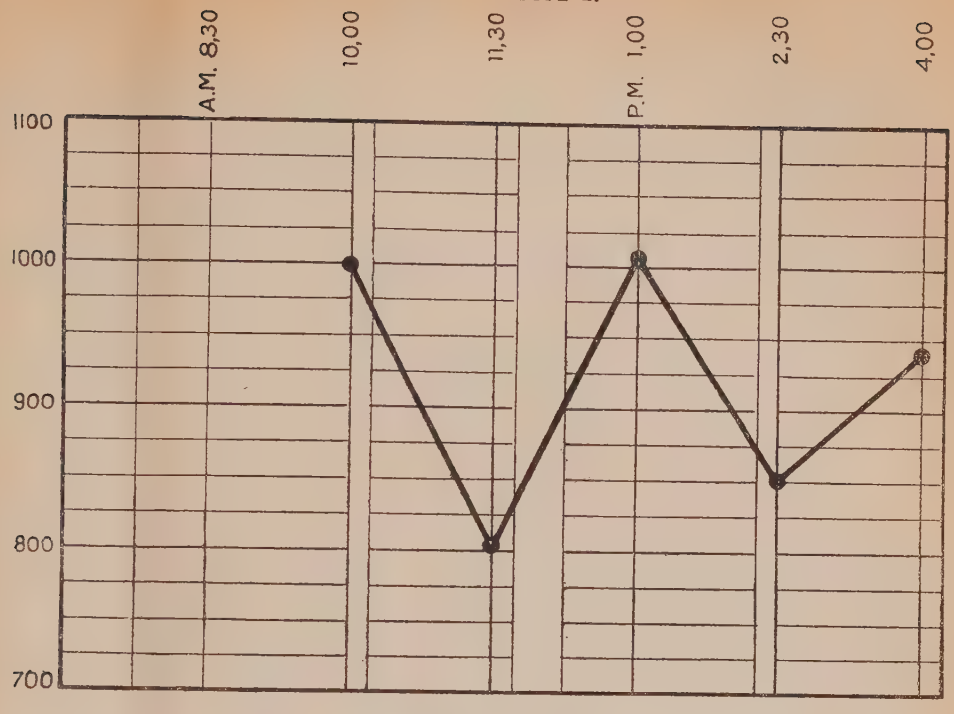


Chart 5. — Type 3.

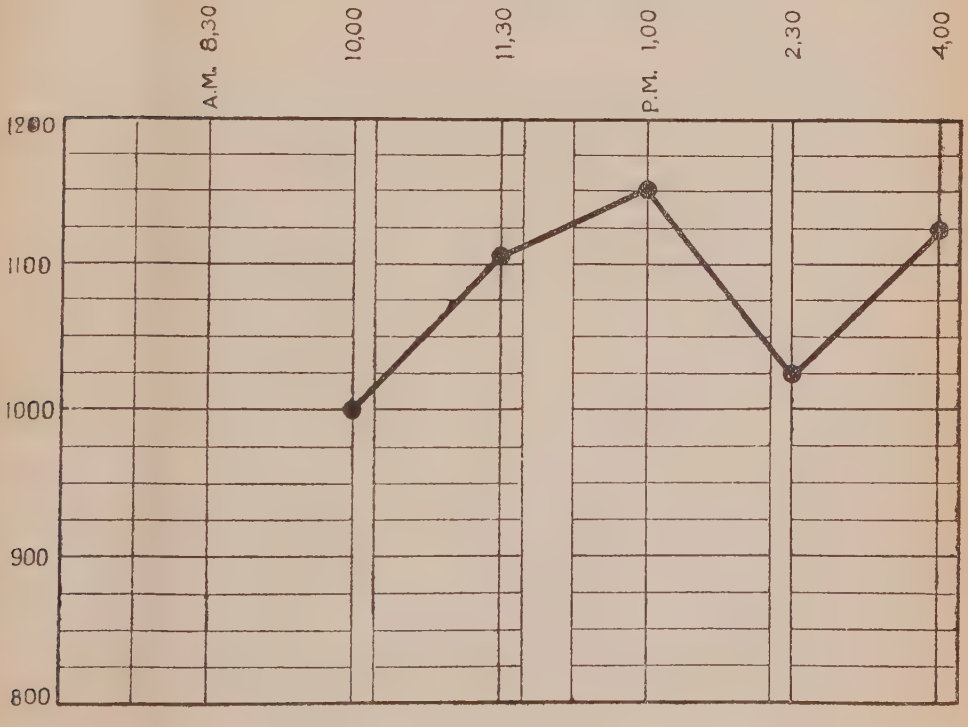


Chart 6. — TYPE 4.

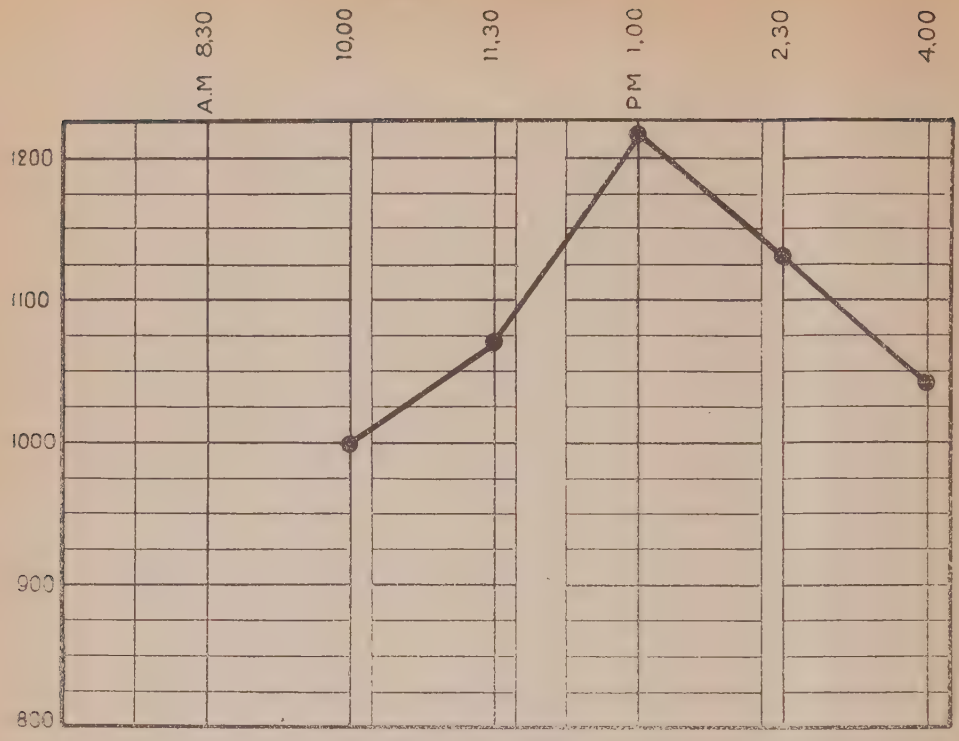
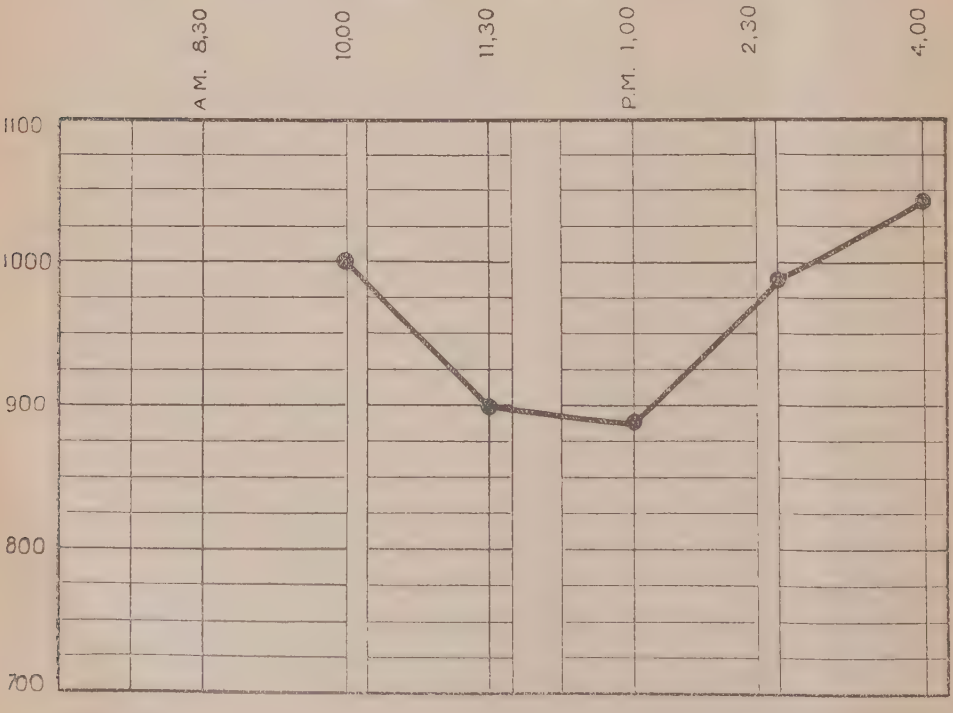


Chart 7. — TYPE 5.



4.

THE MEASUREMENT OF THE BODY SURFACE AREA OF MAN.

By Hideo Takahira

(From the Imperial State Institute for Nutrition, Tokyo).

1. Introduction.

It has been recognised since the experiments of Rubner that the body surface area is the most suitable measurement from which to calculate metabolism. The formula of Meeh, by means of which the body surface area may be calculated from the body weight, was used in metabolic researches for a long time. Eugene F. Du Bois, however, disputed the accuracy of the Meeh formula and found that it had an average error of + 15 per cent, and a maximum error of + 30 per cent.

Eugene F. Du Bois, in collaboration with Delafield Du Bois, devised the linear formula in 1915 and the height-weight formula in 1916. With these formulæ, they could estimate the body surface area with an average error of ± 1.5 per cent, and a maximum error of ± 5 per cent.

In the study of the basal metabolism of Japanese men and women, I used the Du Bois height-weight formula to calculate the body surface area and I expressed the metabolism as a function of the surface unit. However, it requires to be proved whether or not the height-weight formula is applicable in the case of the Japanese, where the ratio of trunk measurement to that of the extremities is different from that of European races. In order to examine the applicability of the height-weight formula and other formulæ to Japanese subjects, I performed the following experiment.

2. Experimental Procedure.

The body surface area of ten men was measured. The method of measurement consisted in making a thin paper mould of the body, cutting this up in small pieces which would lie flat and measuring the area of the paper pieces by Amsler's planimeter. This somewhat resembles the Du Bois' method, but is modified in various points.

The subject's hair was first cut close to the head and then he bathed. He was weighed, placed on a flat table and all the measurements were made. A staple tape was used for all the linear measurements and a cloth tape for the circumferences.

The boundaries of the anatomical regions of the head, trunk, arms, hands, legs and feet were marked with black enamel on the skin.

The material used to cover the body was a very thin and strong paper called Gampishi. If this paper is moistened, it is possible to make it fit very easily even over the fingers, toes and ears. In order to apply the paper closely to the skin, a Japanese writing brush was used. The paper was cut into various shapes and sizes previous to its application.

The paper was pasted on the nude body first with water, then with 1 per cent Shofu starch paste and was then dried with a fan. The holes of the nose and ears were left uncovered. The penis and scrotum were not covered; their surface area was calculated from linear measurements.

When the paper covering (consisting of a double layer of Gampishi over the skin) was dry, it was removed. This mould of the body was then cut into small pieces with scissors and their surface area was measured with Amsler's planimeter No. 4.

The average error of the planimeter per individual measurement was 0.2 per cent and was neglected. To determine the error due to the shrinkage of the paper mould, I pasted some of the paper over the surface of a large rubber balloon. The diameter of the balloon was 21.269 cms., as determined by 20 measurements made with a Universal measuring machine. The theoretical surface area worked out at 1421.17 sq. cms. Ten coverings were made and the error due to the shrinkage of the paper was found to average —1.1 per cent. This percentage of error was corrected in the body surface measurement of each man.

Table 1. — Surface Area of Rubber Balloon.

Expérience N° No. of Experiment	Superficie mesurée (cm²) Surface area measured (sq. cm.)	Ecart de la superficie moyenne Difference from mean value	Ecart % Difference %	Ecart de la superficie calculée Difference from theoretical value	Ecart % Difference %
1	1404.6	—0.87	—0.06	—15.6	—1.10
2	1409.1	+3.63	+0.26	—12.1	—0.85
3	1405.2	—0.27	—0.02	—16.0	—1.19
4	1400.3	—5.17	—0.37	—20.9	—1.40
5	1404.1	—1.37	—0.10	—16.8	—1.18
6	1402.1	—3.37	—0.24	—19.1	—1.34
7	1412.1	+7.33	+0.52	— 9.0	—0.63
8	1399.5	—5.97	—0.43	—21.7	—1.53
9	1409.4	+3.93	+0.28	—11.8	—0.83
10	1407.6	+1.13	+0.15	—13.6	—0.96
Moyenne / Average	1405.5	—	±0.24	—17.3	—1.10

The differences between Du Bois' methods and mine are as follows:

1. Du Bois' paper mould was made over the underwear, socks and cotton gloves, and the surface area of the ears, genitals, fingers and toes were not measured accurately. I made a thin paper mould of the whole nude body except the genitals.

2. Du Bois measured the surface area of the pieces of the paper mould by printing the patterns of these pieces on photographic paper. In my experience this method gives a relatively large error, so I used a planimeter.

3. While Du Bois did not correct for the shrinkage of the paper mould, I made a correction of —1.1 per cent.

3. Experimental Results.

Ten men were measured. The subjects were members or employees of the Institute. The measurements were made from July to October 1923. The age, body weight, body height, body shape, and the actually measured body surface area are presented in Table 2.

The surface area of each portion of the body and its proportion of the total area are shown in Tables 3 and 4.

We found the surface area of the head, trunk, arms, hands, legs and feet averaged 10, 25, 14, 6, 38, and 7 per cent respectively of the total surface area of the body.

Table 2. — Age, Weight, Height and Surface Area measured of the Subjects.

Sujets Subject	Age Années Years	Poids kgs Weight kg.	Taille cm. Height cm.	Superficie $cm.^2$ Surface area sq. cm.	Description du corps Body form
Takahira .	28	51.00	169.60	15923	grand, mince — tall, thin.
Kitagawa .	26	49.50	160.15	14964	normal.
Ishibashi .	22	48.00	162.60	14913	normal.
Kayano .	22	50.10	151.80	14647	modérément gras — moderately fat.
Shimizu . .	18	55.60	163.00	16010	normal.
Tanaka . .	18	41.30	156.50	14593	normal.
Kato . . .	19	55.90	161.50	15621	gros — fat.
Ogishima .	53	51.20	156.20	15425	normal.
Nakamura.	54	37.30	149.60	12793	petit, mince — short, thin.
Kawaguchi	58	50.80	161.90	15304	normal.

Table 3. — Surface Area of the Individual Body Portion.

Sujets Subject	Tête Head	Torse Trunk	Bras Arms	Mains Hands	Jambes Legs	Pieds Feet	Total Totals
Takahira	1555	3973	2323	892	6028	1152	15923
Kitagawa	1473	3637	2117	809	5837	1091	14964
Ishibashi	1514	3774	2187	813	5581	1044	14913
Kayano	1480	3517	2238	731	5631	1050	14647
Shimizu	1464	3732	2244	923	6401	1246	16010
Tanoka	1485	3370	2157	862	5579	1140	14593
Kato	1464	4081	2261	851	5892	1072	15621
Ogishima	1509	4041	2296	870	5608	1101	15425
Nakamura	1444	3138	1832	799	4617	963	12793
Kawaguchi	1484	4099	2177	863	5599	1082	15304

Table 4. — Percentage of the Surface Area of the Individual Body Portion.

Sujets Subject	Tête Head	Torse Trunk	Bras Arms	Mains Hands	Jambes Legs	Pieds Feet	Total Totals
Takahira	10	25	14	6	38	7	100
Kitagawa	10	25	14	5	39	7	100
Ishibashi	10	25	15	5	38	7	100
Kayano	10	24	15	5	39	7	100
Shimizu	9	23	14	6	40	8	100
Tanaka	10	23	15	6	38	8	100
Kato	9	26	14	6	38	7	100
Ogishima	10	26	15	6	36	7	100
Nakamura	11	25	14	6	36	8	100
Kawaguchi	10	27	14	6	36	7	100
Moyenne / Average	10	25	14	6	38	7	100

4. Applicability of Various Formulæ for Computing Surface Area to our Experimental Results.

I subsequently tested the applicability of the various formulæ for estimating the approximate surface area of the body, in the light of actual measurements of the body surface area.

A. *Formulæ for estimating the Body Surface Area from the Body Weight only.*

When the results of actual measurement are applied to Meeh's formula $A = W^{\frac{2}{3}} \times 12.3$, there is an average error of + 9.26 per cent, and a maximal error of + 13.13 per cent. The error is very great and usually positive.

Table 5. — Error of Meeh's Formula (1).

Sujets Subject	Superficie (cm^2.) Surface area sq. cm.	$W^{\frac{2}{3}} \times 12.3$	Difference	Difference %
Takahira	15923	16913	+ 990	+ 5.85
Kitagawa	14964	16580	+ 1616	+ 9.14
Ishibashi	14913	16248	+ 1335	+ 8.22
Kayano	14647	16716	+ 2069	+ 12.38
Shimizu	16010	17921	+ 1911	+ 10.66
Tanaka	14593	15867	+ 1274	+ 8.03
Kato	15621	17983	+ 2362	+ 13.13
Ogishima	15425	16962	+ 1537	+ 9.06
Nakamura	12793	13727	+ 934	+ 6.80
Kawaguchi	15304	16876	+ 1572	+ 9.32
Moyenne — Average	—	—	—	+ 9.26

When 11.15 was used as the constant in the formula $A = W^{\frac{2}{3}} \times C$, the average error was ± 1.91 per cent and the maximum error ± 3.80 per cent. The error was now considerably less; the error is usually negative in a thin man and positive in a fat man. The Meeh formula is therefore not applicable for estimating the body surface area.

Table 6. — Error of Meeh's Formula (2).

Sujets Subject	C	Superficie Surface area	$W^{\frac{2}{3}} \times 11.15$	Difference	Difference %
Takahira	11.58	15923	15340	— 583	— 3.80
Kitagawa.	11.10	14964	15038	+ 74	+ 0.49
Ishibashi	11.29	14913	14732	— 181	— 1.23
Kayano	10.78	14647	15159	+ 512	+ 3.38
Shimizu	10.99	16010	16249	+ 239	+ 1.47
Tanaka	11.32	14593	14382	— 211	— 1.47
Kato.	10.69	15621	16305	+ 686	+ 4.21
Ogishima	11.19	15425	15380	— 45	— 0.29
Nakamura	11.46	12793	12452	— 341	— 2.74
Kawaguchi	11.16	15304	15300	—	— 0.03
Moyenne — Average	11.15	—	—	—	+ 1.91

B. *Formula for estimating the Body Surface Area from the Body Height and Body Weight.*

1. Lissauer's formula, $A = \frac{W}{H} \times C$, using the constant 48.48, gives an average error of ± 4.32 per cent, and a maximum error of ± 9.22 per cent.

Table 7. — Error of Lissauer's Formula.

Sujets Subject	C	Superficie Surface area	$\frac{W}{H} \times 48.48$	Difference	Difference %
Takahira	52.95	15923	14578	— 1345	— 9.22
Kitagawa.	48.41	14964	14984	+ 20	+ 0.14
Ishibashi	50.52	14913	14311	— 602	— 4.20
Kayano	44.38	14647	16000	+ 1353	+ 8.46
Shimizu	46.94	16010	16537	+ 527	+ 3.18
Tanaka	49.33	14593	14343	— 251	— 1.75
Kato.	45.13	15621	16780	+ 1150	+ 6.91
Ogishima	47.06	15425	15891	+ 466	+ 2.93
Nakamura	51.31	12793	12088	— 706	— 5.84
Kawaguchi	48.77	15304	15212	— 93	— 0.61
Moyenne — Average	48.48	—	—	—	± 4.32

2. $A = H \times W^{\frac{1}{3}} \times C$, with the constant 25.69, gave an average error of ± 1.37 per cent, and a maximum error of ± 3.53 per cent.

Table 8. — Error of the Formula $A = H \times W^{\frac{1}{3}} \times C$.

Sujets Subject	C	Superficie Surface area	$H \times W^{\frac{1}{3}} \times 25.69$	Difference	Difference %
Takahira	25.32	15923	16157	+ 234	+ 1.45
Kitagawa	25.45	14964	15106	+ 142	+ 0.94
Ishibashi	25.24	14913	15180	+ 1267	+ 1.76
Kayano	26.17	14647	14376	— 271	— 1.89
Shimizu	25.74	16010	15982	— 28	— 0.18
Tanaka	25.97	14593	14436	— 157	— 1.09
Kato	25.30	15621	15863	+ 242	+ 1.53
Ogishima	26.60	15425	14900	— 525	— 3.53
Nakamura	25.60	12793	12840	+ 47	+ 0.37
Kawaguchi	25.52	15304	15403	+ 99	+ 0.64
Moyenne — Average	25.69	—	—	—	± 1.37

3. When Du Bois' linear formula, $A = H^{\frac{1}{2}} \times W^{\frac{1}{2}} \times 167.2$ was applied to the results of the actual measurement, the average error was ± 1.56 per cent, and the maximum error ± 3.16 per cent. With a constant of 169.2 the error was smaller, the average being ± 1.14 per cent, and the maximum ± 2.82 per cent.

Table 9. — Error of Du Bois' Linear Formula (1).

Sujets Subject	Superficie Surface area	$H^{\frac{1}{2}} \times W^{\frac{1}{2}} \times 167.2$	Difference	Difference %
Takahira	15923	15650	— 373	— 2.40
Kitagawa	14964	14885	— 79	— 0.53
Ishibashi	14913	14772	— 141	— 0.97
Kayano	14647	14581	— 66	— 0.45
Shimizu	16010	15917	— 93	— 0.58
Tanaka	14593	14233	— 360	— 2.53
Kato	15621	15887	+ 266	+ 1.67
Ogishima	15425	14953	— 472	— 3.16
Nakamura	12793	12490	— 303	— 2.43
Kawaguchi	15304	15168	— 136	— 0.90
Moyenne — Average	—	—	—	± 1.56

Table 10. — Error of Du Bois' Linear Formula (2).

Sujets Subject	C	Superficie Surface area	$H^{\frac{1}{2}} \times W^{\frac{1}{2}} \times 169.2$	Difference	Difference %
Takahira	171.21	15923	15735	— 188	— 1.20
Kitagawa.	167.36	14964	15127	+ 163	+ 1.08
Ishibashi	168.81	14913	14947	+ 34	+ 0.22
Kayano	167.96	14647	14754	+ 107	+ 0.73
Shimizu	168.18	16010	16106	+ 96	+ 0.60
Tanaka	171.43	14593	14102	— 192	— 1.33
Kato.	164.41	15621	16075	+ 454	+ 2.82
Ogishima	172.48	15425	15130	— 295	— 1.90
Nakamura	171.26	12793	12638	— 155	— 1.23
Kawaguchi	168.75	15304	15343	+ 39	+ 0.25
Moyenne — Average	169.18	—	—	—	± 1.14

4. Using Du Bois' height-weight formula, $A = H^{.725} \times W^{.425} \times 71.84$, the average error was ± 1.28 per cent, and the maximum error ± 3.50 per cent. With a constant of 72.46, the average error was ± 0.95 per cent, and the maximum error ± 2.64 per cent.

Table 11. — Error of Du Bois' Height-Weight Formula (1).

Sujets Subject	Superficie Surface area	$W^{.425} \times H^{.725} \times 71.84$	Difference	Difference %
Takahira	15923	15790	— 133	— 0.84
Kitagawa	14964	14951	— 13	— 0.09
Ishibashi	14913	14927	+ 14	+ 0.09
Kayano	14647	14459	— 188	— 1.30
Shimizu	16010	15916	— 94	— 0.59
Tanaka	14593	14099	— 494	— 3.50
Kato	15621	15847	+ 226	+ 1.43
Ogishima	15425	14915	— 51	— 3.42
Nakamura.	12793	12652	— 141	— 1.11
Kawaguchi	15304	15243	— 61	— 0.40
Moyenne — Average	—	—	—	± 1.28

Table 12. — Error of Du Bois' Height-Weight Formula (2).

Sujets Subject	C	Superficie Surface area	$W^{.425} \times H^{.725} \times 72.46$	Difference	Difference %
Takahira	72.439	15923	15926	+ 4	+ 0.03
Kitagawa.	71.872	14964	15085	+ 121	+ 0.80
Ishibashi	71.775	14913	15054	+ 141	+ 0.94
Kayano	72.761	14647	14586	— 62	— 0.42
Shimizu	72.260	16010	16053	+ 43	+ 0.27
Tanaka.	73.325	14593	14420	— 173	— 1.20
Kato.	70.816	15621	15983	+ 361	+ 2.26
Ogishima	74.365	15425	15029	— 396	— 2.64
Nakamura	72.807	12793	12731	— 62	— 0.49
Kawaguchi	72.129	15304	15373	+ 69	+ 0.45
Moyenne — Average	72.455	—	—	—	± 0.95

C. *Formulæ for estimating the Body Surface from the Body Height, Body Weight, and Circumference of the Trunk.*

1. Stöltzner-Miwa formula $\frac{UHW}{\sqrt[6]{H^2W^4U^2}} \times C$. Stöltzner and Miwa introduced the circumference of the chest as a factor in the measurement of the body surface. With a constant of 40.42 the average error was ± 1.28 per cent, and the maximum error ± 3.62 per cent.

Table 13. — Error of Stöltzner-Miwa's Formula.

Sujets Subject	C	Superficie Surface area	$\frac{UHW}{\sqrt[6]{H^2W^4U^2}} \times 40.42$	Difference	Difference %
Takahira	41.435	15923	15534	— 389	— 2.50
Kitagawa.	40.935	14964	14777	— 187	— 1.26
Ishibashi	41.095	14913	14669	— 244	— 1.66
Kayano	39.144	14647	15126	+ 479	+ 3.17
Shimizu	39.878	16010	16229	+ 219	+ 1.35
Tanaka	40.618	14593	14523	— 70	— 0.48
Kato.	38.929	15621	16208	+ 587	+ 3.62
Ogishima	41.631	15425	14978	— 447	— 2.99
Nakamura	40.376	12793	12808	+ 15	+ 0.12
Kawaguchi	40.169	15304	15401	+ 97	+ 0.63
Moyenne — Average	40.424	—	—	—	± 1.78

2. Bouchard's formula, $A = C_1 LH + C_2 \frac{H}{L} + C_3 H \sqrt{\frac{W}{\pi H}}$. In this formula, the symbol L signifies the circumference of the waist. Applying the experimental results, I obtained for the three constants, C_1, C_2, C_3, the values of 0.386, 8.239, 3.162 respectively. When these constants were applied in the formula, the average error was ± 1.12 per cent, and the maximum error ± 2.91 per cent.

Table 14. — Error of Bouchard's Formula.

Sujets Subject	C_1	C_2	C_3	Superficie Surface area	$C_1LH+C_2\frac{H}{L}+C_3H\sqrt{\frac{W}{\pi H}}$	Diff.	Diff. %
Takahira . . .	0.384	8.482	3.199	15923	15745	— 178	— 1.13
Kitagawa . .	0.387	8.112	3.140	14964	15072	+ 108	+ 0.72
Ishibashi . . .	0.377	8.389	3.154	14913	14957	+ 44	+ 0.29
Kayano . . .	0.395	7.942	3.138	14647	14766	+ 119	+ 0.81
Shimizu . . .	0.376	8.351	3.142	16010	16117	+ 107	+ 0.65
Tanaka . . .	0.391	8.352	3.203	14593	14409	— 184	— 1.28
Kato	0.388	7.731	3.072	15621	16090	+ 469	+ 2.91
Ogishima. . .	0.399	8.285	3.223	15425	15139	— 286	— 1.80
Nakamura . .	0.385	8.460	3.200	12793	12646	— 147	— 1.16
Kawaguchi .	0.382	8.285	3.153	15304	15352	+ 48	+ 0.31
Moyenne Average.	0.386	8.239	3.162	—	—	—	± 1.12

D. *Geometrical Measurement.*

The linear measurements of the body were made with the subjects lying on a flat table. The surface area of each portion of the body was expressed as the product of the circumference, length and a constant. The following measurements were made:

A — circumference passing vertex and point of chin.
B — coronal circumference around occiput and forehead, just above eyebrows.
F — tip of acromial process to lower border of radius, measured with forearm extended.
G — circumference at level of upper border of axilla.
H — largest circumference of forearm.
I — smallest circumference of forearm.
J — lower posterior border of radius to tip of second finger.
K — circumference of open hand at the metacarpo-phalangeal joints.
L — suprasternal notch to upper border of pubes.
M — circumference of abdomen at level of umbilicus.
N — circumference of thorax at level of nipples in the male, and just above the breasts in the female.

O — superior border of great trochanter to the lower border of the patella.
P — circumference of thigh just below the level of the perineum.
Q — circumference of hips and buttocks at the level of the great trochanters.
W — upper border of pubes to lower border of the patella.
R — from sole of foot to lower border of patella.
S — circumference at level of lower border of patella.
T — length of foot including great toe.
U — circumference of foot at base of little toe.
V — smallest circumference of ankle.

The value of each linear measurement is represented in Table 15.

The surface area of the various parts of the body is expressed in the following formulæ:

$$\text{Head} = A\,B \times C$$
$$\text{Trunk} = (M + N)\,L \times C$$
$$\text{Arm} = (G + H + I)\,F \times C$$
$$\text{Hand} = J\,K \times C$$
$$\text{Leg} = (P + S + V)\,(W + R) \times C$$
$$\text{Foot} = T\,U \times C$$

The value of the constants is as in Table 16.

When the formulæ were applied to the results obtained by actual measurements, the average error was ± 2.24 per cent, and the maximum error ± 5.43 per cent. The method was very complicated and the error was relatively large.

Table 15. — Linear Measurement.

Sujets Subject	Takahira	Kitagawa	Ishibashi	Kayano	Shimizu	Tanaka	Kato	Ogishima	Nakamura	Kawaguchi
A.	70.0	67.5	67.0	67.0	66.0	66.0	65.5	65.75	64.5	66.25
B.	55.0	54.0	53.5	56.0	54.0	56.5	55.0	54.5	54.5	54.75
L.	53.0	49.5	53.0	49.0	54.0	50.0	53.0	49.75	50.0	52.0
W.	42.5	39.0	38.0	36.0	38.0	36.5	38.0	37.75	32.0	37.0
R.	43.5	39.5	40.5	37.5	42.5	40.5	40.5	37.0	40.5	42.0
O.	41.25	36.0	39.0	36.5	36.5	39.0	37.0	39.0	35.0	35.75
T.	26.0	23.0	23.5	22.0	25.0	23.5	24.0	23.0	23.0	23.5
F.	56.5	52.0	50.0	49.5	53.0	54.0	51.0	49.0	50.5	51.25
J.	20.5	16.0	17.75	15.8	20.0	20.0	18.5	18.75	18.0	19.0
N.	81.0	78.5	78.25	83.0	84.5	80.0	84.5	79.75	75.5	82.0
M.	65.0	64.0	62.5	67.0	66.0	61.0	72.5	72.0	56.5	66.25
Q.	81.5	80.5	81.0	81.5	87.5	79.5	83.0	82.5	74.0	82.5
P	43.75	46.0	47.5	50.8	52.0	46.0	48.75	47.25	36.0	45.5
S.	31.5	32.5	31.5	32.5	34.5	31.0	22.0	30.5	27.5	31.0
.	18.75	19.0	18.75	20.0	22.5	16.5	20.5	19.5	17.0	18.25
U.	22.25	24.5	20.5	23.0	24.5	22.5	22.5	22.75	21.0	22.0
G.	25.0	23.5	25.5	28.0	25.0	23.5	27.5	26.75	21.5	25.5
H.	23.5	23.5	23.5	25.0	25.5	23.0	25.5	23.75	21.0	24.2
I.	15.5	15.0	15.75	16.0	18.0	16.5	17.5	16.75	13.5	15.25
K.	19.0	18.5	19.0	17.0	21.5	20.0	20.0	19.5	18.0	19.25

Table 16. — Constants of Linear Formulæ.

Sujets Subject	Tête Head	Torse Trunk	Bras Arms	Mains Hands	Jambes Legs	Pieds Feet
Takahira	0.4039	0.5134	0.6424	2.2900	0.7457	1.9914
Kitagawa	0.4041	0.5156	0.6566	2.7331	0.7626	1.9361
Ishibashi	0.4224	0.5059	0.6755	2.4125	0.7273	2.1671
Kayano	0.3945	0.4785	0.6552	2.7215	0.7416	2.0751
Shimizu	0.4108	0.4592	0.6181	2.1465	0.7295	2.0343
Tanaka	0.3982	0.4780	0.6340	2.1550	0.7749	2.1560
Kato	0.4064	0.4904	0.6288	2.3000	0.6585	1.9852
Ogishima	0.4211	0.5352	0.6968	2.3800	0.7715	2.1042
Nakamura	0.4108	0.4818	0.6478	0.4660	0.7911	1.9938
Kawaguchi	0.4091	0.5317	0.6560	2.3593	0.7480	2.0928
Moyenne / Average	0.4081	0.4990	0.6511	2.3964	0.7451	2.0536

Table 17. — Error of Geometrical Measurement.

Sujets Subject	Superficie réelle Surface area	Superficie calculée Calculated area	Difference	Difference %
Takahira	15923	15930	+ 7	+ 0.04
Kitagawa	14964	14676	— 288	— 1.96
Ishibashi	14913	14808	— 105	— 0.71
Kayano	14647	14763	+ 116	+ 0.79
Shimizu	16010	16699	+ 689	+ 4.13
Tanaka	14593	14664	+ 710	+ 0.48
Kato	15621	16626	+ 1005	+ 6.04
Ogishima	15425	14817	— 804	— 5.43
Nakamura	12793	12685	— 108	— 0.85
Kawaguchi	15304	15004	— 300	— 2.00
Moyenne — Average	—	—	—	± 2.24

5. Discussion of the Results.

A simple formula for estimating the body surface area would naturally be preferable to a more complicated one; however, with a simple formula, we do not obtain as accurate results.

The formula for calculating the body surface area from the body weight only — for instance — Meeh's formula, usually gave too high results. When the constant was changed, the result was too high in a thin person and too low in an obese person.

This type of formula is not therefore suitable for the calculation of the body surface area.

The formula for calculating the body surface area from the body height and body weight was the best one. The following three formulæ devised by Du Bois gave good results.:

$$A = H \times W^{\frac{1}{3}} \times C$$

$$A = H^{\frac{1}{2}} \times W^{\frac{1}{2}} \times C$$

$$A = H^{.725} \times W^{.425} \times C$$

If the constant was changed to 169.2 in Du Bois' linear formula, the average error was ± 1.14 per cent and the maximum error ± 2.82 per cent. If the constant was changed to 72.46 in Du Bois' height-weight formula, the average error was ± 0.95 per cent and the maximum error ± 2.64 per cent. This modified Du Bois' height-weight formula gave the least error.

The more complicated formula of Stöltzner-Miwa, which employed, besides the body height and body weight, as an additional factor the circumference of the trunk, was not so good. Bouchard's formula gave relatively better results.

The geometrical measurements gave rather poor results and were very complicated.

Table 18. — Summarising Table.

Auteur Author	Formule Formulæ	Erreur moyenne Average error %	Erreur maximum Maximum error %
Meeh	$A = W^{\frac{2}{3}} \times 12.3$	+ 9.26	+ 12.38
——	$A = W^{\frac{2}{3}} \times 11.15$	± 1.91	± 4.21
Lissauer	$A = \frac{W}{H} \times 48.48$	± 4.32	± 9.22
——	$A = H \times W^{\frac{1}{3}} \times 25.47.$	± 1.37	± 3.53
Du Bois-Du Bois	$A = H^{\frac{1}{2}} \times W^{\frac{1}{2}} \times 167.2$	± 1.56	± 3.16
——	$A = H^{\frac{1}{2}} \times W^{\frac{1}{2}} \times 169.2$	± 1.14	± 2.82
Du Bois-Du Bois	$A = H^{.725} \times W^{.125} \times 71.84$	± 1.28	± 3.50
——	$A = H^{.725} \times W^{.425} \times 72.46$	± 0.95	± 2.64
Stöltzner-Miwa	$A = \frac{U H W}{\sqrt[6]{H^4 W^4 U^2}} \times 40.42$	± 1.78	± 3.62
Bouchard	$A = 0.386LH + 8.239 \frac{W}{L} + 3.162H\sqrt{\frac{W}{\pi H}}$	± 1.12	± 2.91
	Mesure géométrique Geometrical measurement	± 2.24	± 5.43

A formula for expressing surface area must naturally be a bi-dimensional one, as surface involves two dimensions. If we assume that weight is proportional to volume, it is obvious that three dimensions are involved in any measurement expressing weight. Height is, of course, a single dimension. The three formulæ $A = H \times W^{\frac{1}{3}} \times C$, $A = H^{\frac{1}{2}} \times W^{\frac{1}{2}} \times C$, and $A = H^{.725} \times W^{.425} \times C$ are bi-dimensional and logical.

Using the general formula $A = W^{\frac{1}{a}} \times H^{\frac{1}{b}} \times C$, if $\frac{2}{a} + \frac{1}{b} = 2$ and $2 > b > 1$, according to Du Bois a good result is obtained when $a = 2.35$ and $b = 1.38$. I find that if $a = 2.34$ and $b = 1.39$ the minimum error is obtained. The formula $A = W^{.427} \times H^{.718} \times 74.49$ gives an average error of $\pm$ 0.94 per cent and a maximum error of $\pm$ 2.62 per cent.

Table 19. — FORMULÆ, IN WHICH $\frac{2}{a} + \frac{1}{b} = 2$ AND $2 > b > 1$.

No.	Formules Formulæ		C	Erreur moyenne Average error	Erreur maxim Maximal error
1	$W^{\frac{1}{3}} \times H^{\frac{1}{1}} \times C$	$W^{.333} \times H^{1.000} \times C$	25.689	$\pm$1.336	+3.527
2	$W^{\frac{1}{2.9}} \times H^{\frac{1}{1.04}} \times C$	$W^{.345} \times H^{.966} \times C$	29.164	$\pm$1.269	+3.414
3	$W^{\frac{1}{2.8}} \times H^{\frac{1}{1.08}} \times C$	$W^{.357} \times H^{.938} \times C$	32.077	$\pm$1.207	+3.312
4	$W^{\frac{1}{2.7}} \times H^{\frac{1}{1.13}} \times C$	$W^{.370} \times H^{.889} \times C$	39.090	$\pm$1.119	+3.168
5	$W^{\frac{1}{2.6}} \times H^{\frac{1}{1.18}} \times C$	$W^{.385} \times H^{.846} \times C$	45.852	$\pm$1.073	+3.026
6	$W^{\frac{1}{2.5}} \times H^{\frac{1}{1.25}} \times C$	$W^{.400} \times H^{.800} \times C$	54.607	$\pm$1.024	+2.879
7	$W^{\frac{1}{2.4}} \times H^{\frac{1}{1.33}} \times C$	$W^{.417} \times H^{.750} \times C$	65.851	$\pm$0.976	+2.716
8	$W^{\frac{1}{2.3}} \times H^{\frac{1}{1.44}} \times C$	$W^{.435} \times H^{.696} \times C$	80.722	$\pm$0.947	+2.541
9	$W^{\frac{1}{2.2}} \times H^{\frac{1}{1.57}} \times C$	$W^{.455} \times H^{.637} \times C$	100.659	$\pm$0.997	—2.461
10	$W^{\frac{1}{2.1}} \times H^{\frac{1}{1.75}} \times C$	$W^{.476} \times H^{.571} \times C$	129.637	$\pm$1.000	—2.648
11	$W^{\frac{1}{2.0}} + H^{\frac{1}{2.0}} \times C$	$W^{.500} \times H^{.500} \times C$	169.184	$\pm$1.140	—2.824
1	$W^{\frac{1}{2.39}} \times H^{\frac{1}{1.34}} \times C$	$W^{.418} \times H^{.745} \times C$	67.279	$\pm$0.967	+2.702
2	$W^{\frac{1}{2.38}} \times H^{\frac{1}{1.35}} \times C$	$W^{.420} \times H^{.740} \times C$	68.470	$\pm$0.964	+2.685
3	$W^{\frac{1}{2.37}} \times H^{\frac{1}{1.36}} \times C$	$W^{.422} \times H^{.734} \times C$	70.036	$\pm$0.955	+2.644
4	$W^{\frac{1}{2.36}} \times H^{\frac{1}{1.37}} \times C$	$W^{.424} \times H^{.729} \times C$	71.278	$\pm$0.955	+2.648
5	$W^{\frac{1}{2.35}} \times H^{\frac{1}{1.38}} \times C$	$W^{.426} \times H^{.723} \times C$	72.909	$\pm$0.949	+2.628
6	$W^{\frac{1}{2.34}} \times H^{\frac{1}{1.39}} \times C$	$W^{.427} \times H^{.718} \times C$	74.490	$\pm$0.943	+2.615
7	$W^{\frac{1}{2.33}} \times H^{\frac{1}{1.40}} \times C$	$W^{.429} \times H^{.712} \times C$	76.192	$\pm$0.944	+2.598
8	$W^{\frac{1}{2.32}} \times H^{\frac{1}{1.41}} \times C$	$W^{.431} \times H^{.709} \times C$	77.543	$\pm$0.945	+2.578
9	$W^{\frac{1}{2.31}} \times H^{\frac{1}{1.43}} \times C$	$W^{.433} \times H^{.701} \times C$	79.318	$\pm$0.946	+2.558

In summarising the results, I would say that Du Bois' original height-weight formula is applicable for Japanese subjects. But results showing the least error can be obtained by the following two formulæ:

$$A = H^{\cdot 725} \times W^{\cdot 425} \times 72.46.$$
$$A = H^{\cdot 718} \times W^{\cdot 427} \times 74.49.$$

In these formulæ the average error is $\pm$ 0.94 to 0.95 per cent, and the maximum error $\pm$ 2.62 to 2.64 per cent.

Bouchard's formula $A = C_1 L H + C_2 \frac{W}{L} + C_3 H \sqrt{\frac{W}{\pi}}$ gives better results when for the constants C_1, C_2, C_3 the values of 0.386, 8.239 and 21.62 respectively are applied.

6. Summary.

The body surface area of ten men was actually measured. The method of measurement consisted in making a thin paper mould of the body and cutting this mould into small pieces which would lie flat; the area of the paper was then measured by Amsler's planimeter. The shrinkage of the paper mould was allowed for.

It was found that the proportion of the surface area of the head, trunk, arms, hands, legs and feet averaged 10, 25, 14, 6, 38 and 7 per cent respectively of the total surface area of the body.

The applicabilities of the various formulæ for estimating body surface area were tested. The formula for calculating body surface area from the body weight only is not reliable. The bi-dimensional formulæ using both body height and body weight are the best. The formulæ which employ any additional factor, such as the circumference of the chest or hip, are not so good. The geometrical measurements give poor results.

Du Bois' height-weight formula gave the best results; for Japanese subjects, the following two formulæ give the least error:

$$A = H^{\cdot 725} \times W^{\cdot 425} \times 72.46.$$
$$A = H^{\cdot 718} \times W^{\cdot 427} \times 74.49.$$

With these formulæ the average error is $\pm$ 0.94 to 0.95 per cent and the maximum error $\pm$ 2.62 to 2.64 per cent.

5.

METABOLISM DURING FASTING AND SUBSEQUENT RE-FEEDING

By Hideo Takahira.

(From the Imperial State Institute for Nutrition, Tokyo.)

1. Introduction and Experimental Procedures.

Deprived of food, the organism must naturally subsist upon its own body substance and derive the energy necessary for maintaining its functional activity from such stores as are already present in its tissues. Under these circumstances the metabolic processes are reduced to a minimum, because in prolonged inanition the organism tends to spare its material resources. The metabolism during fasting has received much attention ever since the problems of nutrition have been subjected to scientific enquiry.

Ever since Professor Luciani did his famous metabolism experiment on the professional faster Succi, fasting men have frequently served as subjects for metabolic investigations. The most completely studied human fast is, perhaps, that of Levanzin, performed by Benedict and his collaborators of the Nutrition Laboratory of the Carnegie Institute of Washington.

I studied six cases of men who fasted from 12–30 days. In five of the cases, the metabolic experiments were carried out both during fasting and during subsequent re-feeding. The experimental subjects were as follows:

1. H. Takahira (the author): 27 years old, thin man of 50 kgs. body weight and 169 cms. body height; fasted 12 days in 1922 and 14 days in 1923.
2. K. Shigeta: a lawyer, 29 years old, thin man of 43 kgs. body weight and 155 cms. body height; fasted 16 days in 1922.
3. I. Yamana: a priest, 27 years old, moderately well nourished, of 51 kgs. body weight and 158 cms. body height; decreased his diet six days (1,174 calories in first two days, 569 calories in second two days, and 244 calories in last two days) and then fasted 17 days in 1922.
4. T. Ito: a Shinto priest, 29 years old, very obese man of 78 kgs. body weight and 156 cms. body height; fasted 26 days in 1922.
5. K. Takagoromo: a school-teacher, 35 years old, moderately well nourished, of 58 kgs. body weight and 169 cms. body height; fasted 30 days in 1922.

2. The Loss of Body Weight.

The loss of body weight, roughly speaking, expresses the total loss of body material. The weight of every subject was measured daily at 8 a.m., the bladder being emptied immediately before the weighing. The amount of water drunk during each fast day was constant, namely, 800 cc. by Takahira, 700 cc. by Shigeta, 800 cc. by Yamana, and 1,000 cc. by Ito and Takagoromo. On the first fast day, castor oil was administered and the contents of the intestines were emptied.

Table 1. — Change of Body Weight during Fasting

(Body Weight in kgs.)

Jours Days	Takahira	Takahira	Shigeta	Yamana	Ito	Takagoromo
Poids avants le jeûne. — Before fasting.						
1	50.20	50.50	43.30	50.55	77.10	58.85
Poids pendant le jeûne. — During fasting.						
1	50.40	49.40	43.50	* 50.85	77.20	58.40
2	49.00	48.40	42.60	* 50.30	75.60	56.85
3	47.60	47.50	41.80	* 49.65	74.70	56.20
4	46.10	46.60	40.80	* 48.85	73.35	55.20
5	45.40	45.80	39.90	* 48.10	72.50	54.20
6	44.90	45.50	39.00	* 47.60	71.80	53.90
7	44.55	45.10	38.20	46.90	71.00	53.30
8	44.20	44.70	38.00	46.25	70.60	52.80
9	43.90	44.20	37.80	45.95	70.35	52.35
10	43.60	43.90	37.40	45.85	70.00	52.00
11	43.30	43.50	37.00	45.10	69.80	51.55
12	42.90	43.10	36.80	44.85	69.60	51.05
13		42.70	36.50	44.55	69.20	50.85
14		42.40	36.30	44.15	69.00	50.20
15			36.20	44.00	68.50	50.05
16			36.10	43.70	68.20	49.70
17				43.60	67.95	49.55
18				43.15	67.55	49.25
19				42.95	67.20	48.95
20				42.60	66.80	48.55
21				42.40	66.40	48.30
22				42.00	66.10	47.90
23				41.80	65.40	47.60
24					65.10	47.40
25					64.75	49.15
26					64.65	46.80
27						46.40
28						46.00
29						45 85
30						45.45
Poids après le jeûne. — After fasting.						
1	42.60	42.20	36.00	41.35	64.40	44.95

* Diète progressive. — Decreased diet.

Table 2. — Change of Body Weight during Fasting.
(Body Weight in percentages.)

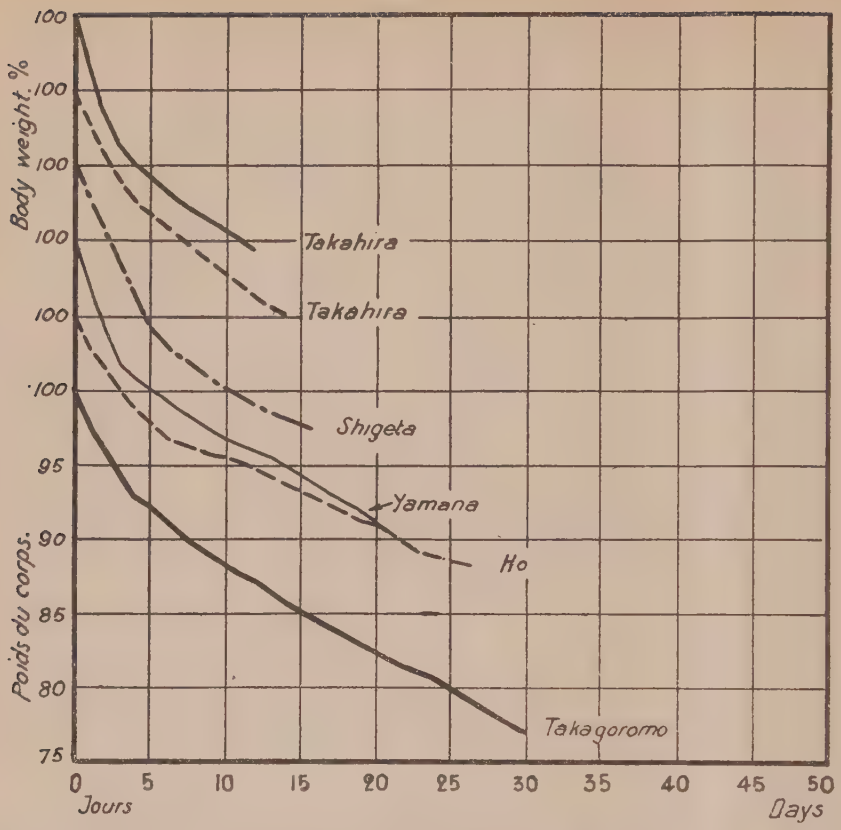
Jours Days	Takahira	Takahira	Shigeta	Yamana	Ito	Takagoromo
1	97.2	98.0	97.9	97.6	97.9	97.4
2	94.4	96.2	96.1	94.6	96.8	96.2
3	91.5	94.3	93.8	92.2	95.0	94.5
4	90.1	92.7	91.7	91.0	93.9	92.8
5	89.3	92.1	89.7	90.4	93.1	92.3
6	88.4	91.3	87.8	89.8	92.0	91.3
7	87.4	90.5	87.4	88.7	91.6	90.4
8	87.3	89.5	86.9	88.2	91.1	89.6
9	86.5	88.9	86.0	87.6	90.7	89.0
10	85.9	88.1	85.1	86.8	90.4	88.3
11	85.3	87.2	84.6	86.5	90.2	87.4
12	84.5	86.4	83.9	85.9	89.6	87.2
13		85.8	83.4	85.7	89.4	86.0
14		85.4	83.2	84.9	88.4	85.7
15			83.0	84.5	88.3	85.1
16			82.8	83.8	88.0	84.8
17				83.2	87.5	84.3
18				82.6	87.0	83.3
19				82.2	86.5	83.1
20				81.3	86.0	82.7
21					85.6	82.0
22					84.7	81.5
23					84.3	81.2
24					83.9	80.7
25					83.7	80.1
26					83.4	79.5
27						78.8
28						78.5
29						77.8
30						77.0

The daily change of body weight is represented in Table 1. Table 2 represents the change of body weight as a percentage of the original weight. Chart 1 represents the change of weight graphically.

The loss of body weight in the first few days of the fast is relatively large, but, after a week's fast, the daily loss of weight becomes smaller and practically constant. The curve of body weight begins as a hyperbola but after a week it becomes a straight line.

Since a reasonable regularity was shown in the course of the curve, a formula was devised, according to the method of Lange, to express the change in weight.

Chart 1.



Using W to represent the weight in kilograms and T the time in days, the weight for any given day may be found by the following equations:

Takahira . . .	W = 7.8 (10)	— 0.195 T	— 0.624 T	+ 92.2
Takahira . . .	W = 4.2 (10)	— 0.194 T	— 0.743 T	+ 95.8
Shigeta . . .	W = 8.5 (10)	— 0.544 T	— 0.544 T	+ 91.5
Yamana . .	W = 7.0 (10)	— 0.215 T	— 0.584 T	+ 93.0
Ito	W = 5.0 (10)	— 0.190 T	— 0.446 T	+ 95.0
Takagoromo .	W = 6.3 (10)	— 0.146 T	— 0.557 T	+ 93.0

According to the classical researches of Chossat, the maximum loss which an organism is able to survive is about 40 per cent of its initial weight; beyond this death from exhaustion usually supervenes. This dictum can no longer be accepted, as we know that the final loss of weight depends on a number of factors, *e.g.*, the store of fat in the body, the size of the body, age, etc. However, roughly speaking, it is true in the case of the higher mammals.

Before 40 per cent of the initial weight was lost, the following periods would elapse:

Takahira	50	days
Takahira	48	»
Shigeta	56	»

Yamana	57	days
Ito	79	»
Takagoromo	61	»

In thin men and moderately well nourished men, this loss takes from 50 to 60 days, but in very obese men it takes 80 days.

On the last fast day the total loss of body weight was as follows:

Sujets Subject	Jour du jeûne Day of fast	Poids au commencement Initial weight (kgs.)	Diminution du poids Loss of weight (kgs.)	Pourcentage de diminution Percentage of loss
Takahira . . .	12th	50.40	7.80	15.5
Takahira . . .	14th	49.40	7.20	14.6
Shigeta. . . .	16th	43.50	7.50	17.2
Yamana	20th	50.85	8.50	18.7
Ito	26th	77.20	12.80	16.6
Takagoromo . .	30th	58.40	13.45	23.0

Avrorov divided a fasting period into four separate periods, each covering the time taken for the body to lose 10 per cent of its weight. Using his terminology, the fasts in our five subjects did not proceed beyond the middle of the second period, except in the case of Takagoromo, whose fast proceeded to the beginning of the third period.

After 12 fast days the loss of body weight in each subject was as follows:

Sujets Subject	Poids au commencement Initial weight (kgs.)	Diminution du poids Loss of weight (kgs.)	Pourcentage de diminution Percentage of loss	Superficie du corps au début Initial body surface (sq. m.)	Diminution de poids par unité de surface Loss in kgs. per surface unit
Shigeta . . .	43.50	7.00	16.1	1.39	5.04
Takahira . . .	50.40	7.80	15.5	1.57	4.99
Takahira . . .	49.40	6.70	13.6	1.57	4.29
Yamana . . .	50.85	7.15	14.1	1.50	4.77
Takagoromo .	58.40	7.55	12.9	1.66	4.55
Ito	77.20	8.00	11.1	1.77	4.52

It is evident that the percentage loss of body weight varies in proportion to the initial weight, but the loss in square meters of body surface is practically constant in each subject. The body surface law of Rubner is applicable to the loss of body weight in fasting men.

3. Basal Metabolism.

The gaseous exchange was examined with a Benedict and Tompkins clinical respiration apparatus every other day. The experiments lasted about two to three hours each morning. The heat production was determined by indirect calorimetry, and the basal metabolism per square meter of body surface per hour was calculated. For details of the gaseous exchange, heat production, pulse rate and respiration rate, see Tables to 37.

The basal metabolism before the fast was 37.66 calories in Takahira, 38.74 calories in Shigeta, 37.60 calories in Yamana, 39.17 calories in Ito, and 38.28 calories in Takagoromo. This averages 38.29 calories and agrees with the basal value of normal Japanese men.

In the course of the fast the metabolism was reduced to the physiological minimum. In Takahira, from the 8th to the 12th fast day, the metabolism was 31.76 to 30.45 calories. In Shigeta, from the 10th to the 16th fast day, it was 33.85 to 30.09 calories. In Yamana, from the 10th to the 20th fast day, it was 33.85 to 28.28 calories. In Ito, from the 10th to the 26th fast day, it was 32.53 to 28.69 calories. And in Takagoromo, from the 4th to the 30th day, it was from 31.95 to 25.97 calories.

The metabolism reached its new low level after the loss of about 10 per cent of the original weight, *i.e.*, at the beginning of the second period. However, in the course of the second period the metabolism still decreased constantly though slowly.

For Takahira, Shigeta, Yamana and Ito, the fast did not proceed beyond the middle of the second period, and their basal metabolism ranged from 33 to 28 calories, the average being 30 calories. The fast of Takagoromo proceeded to the beginning of the third period, and his basal metabolism was reduced to 26 calories.

By the last fast day the basal metabolism was reduced to the extent shown in the following table:

Sujets Subject	Jour de jeûne Day of fast	Métabolisme au commencement Initial metabolism	Métabolisme à la fin Final metabolism	Diminution du métabolisme Decrease of metabolism %
Takahira . . .	12th	37.66	30.45	19
Shigeta	16th	38.74	30.09	22
Yamana	20th	37.60	28.28	25
Ito	26th	39.17	28.69	27
Takagoromo . .	30th	38.28	25.97	32

During the first few days of the fast the basal metabolism did not decrease, but rather increased above the normal value. In Takahira it reached 40.50 calories on the 2nd fast day, in Shigeta 39.40 calories on the 4th fast day and in Ito 41.11 and 40.56 calories on the 2nd and 4th fast days. This was due to an increased oxygen consumption. The carbon dioxide production decreased constantly during the fast. This increased metabolism may be due to increased protein catabolism. The disintegration of body protein decreases during the first fast day, but increases from the 2nd to the 5th fast days. The temporary increase of metabolism is probably due to the specific dynamic action of the catabolised proteins.

Table 3. — METABOLISM OF TAKAHIRA

Jour de l'expérience Day of experiment	Consommation de O^2 pr heure O_2 consumption per hour (l.)	Production de CO^2 par heure CO_2 production per hour (l.)	R.Q.	Calories par m^2 et par heure Calories per sq. m. per hour	Pouls Pulse rate	Respiration Respiration rate	Cal. d'orig. protéique Protein calories %	Autres cal. Non-protein calories %
Avant le jeûne — Before fasting								
1	12.09	11.22	0.93	37.66	61	17	19	81
Pendant le jeûne — During fasting								
2	13.55	9.79	0.76	40.50	87	23	18	82
4	12.22	9.46	0.77	39.12	82	23	21	79
6	10.08	7.72	0.76	31.82	81	20	24	76
8	10.07	7.76	0.77	31.76	81	21	25	75
10	10.28	7.47	0.73	31.83	74	20	25	75
12	9.64	7.24	0.75	30.45	81	20	25	75
Après le jeûne — After fasting								
2	7.43	7.84	1.05	24.11	65	18	55	45
4	8.54	9.12	1.06	26.63	66	17	49	51
8	12.04	13.13	1.09	37.69	65	20	38	62
10	13.42	13.48	1.00	41.30	66	20	35	65

Table 4. — METABOLISM OF SHIGETA.

Jour de l'expérience Day of experiment	Consommation de O^2 pr heure O_2 consumption per hour (l.)	Production de CO^2 par heure CO_2 production per hour (l.)	R.Q.	Calories par m^2 et par heure Calories per sq. m. per hour	Pouls Pulse rate	Respiration Respiration rate	Cal. d'orig. protéique Protein calories %	Autres cal. Non-protein calories %
Avant le jeûne — Before fasting								
1	11.03	10.12	0.91	38.74	57	15	17	83
Pendant le jeûne — During fasting								
1	10.99	10.20	0.94	38.18	57	15	14	86
2	10.96	8.51	0.74	36.35	57	14	28	72
4	11.41	8.51	0.75	39.14	86	17	29	71
6	10.81	8.81	0.80	38.31	88	20	27	73
8	10.95	7.83	0.71	35.95	81	16	37	63
10	9.72	7.28	0.74	33.85	78	16	34	66
12	9.46	7.33	0.76	33.74	86	19	33	67
14	8.81	7.10	0.80	32.03	84	18	31	69
16	8.26	7.16	0.87	30.09	61	15	50	50
Après le jeûne — After fasting								
2	8.57	8.47	0.98	32.22	89	14	42	58
4	9.52	9.54	1.00	37.44	54	14	19	81
6	8.72	8.64	0.99	32.97	51	14	19	81
8	10.06	9.90	0.98	35.67	59	14	34	66

Table 5. — METABOLISM OF YAMANA.

Jour de l'expérience Day of experiment	Consommation de O^2 pr heure O_2 consumption per hour (l.)	Production de CO^2 par heure CO_2 production per hour (l.)	R.Q.	Calories par m^2 et par heure Calories per sq. m. per hour	Pouls Pulse rate	Respiration Respiration rate	Cal. d'orig. protéique Protein calories %	Autres cal. Non-protein calories %
Avant le jeûne — Before fasting								
1	11.51	10.88	0.95	37.60	67	20	14	86
Nourriture diminuée — Decreased Diet								
2	10.60	8.46	0.89	35.15	60	18	12	88
4	11.85	8.61	0.73	37.71	62	20	14	86
Pendant le jeûne — During fasting								
1	10.66	8.15	0.77	33.76	62	22	22	78
3	11.76	8.72	0.74	38.36	62	22	22	78
5	10.97	8.25	0.75	35.98	58	19	21	79
7	10.28	7.58	0.74	33.85	—	18	19	81
9	10.40	7.22	0.69	32.73	—	19	20	80
11	10.01	7.29	0.73	33.26	64	20	18	82
13	9.39	7.17	0.76	31.54	64	17	19	81
15	9.53	7.20	0.76	32.16	—	19	20	80
17	8.25	6.71	0.81	28.28	—	16	23	77
Après le jeûne — After fasting								
2	7.58	7.01	0.92	27.35	68	18	15	85
4	6.36	6.19	0.97	22.67	56	15	22	78
6	7.27	7.93	1.09	25.96	59	18	18	82
8	8.09	9.06	1.12	28.51	57	16	21	79

Table 6. — METABOLISM OF ITO.

Jour de l'expérience Day of experiment	Consommation de O^2 pr heure O_2 consumption per hour (l.)	Production de CO^2 par heure CO_2 production per hour (l.)	R.Q.	Calories par m^2 et par heure Calories per sq. m. per hour	Pouls Pulse rate	Respiration Respiration rate	Cal. d'orig. protéique Protein calories %	Autres cal. Non-protein calories %
Avant le jeûne — Before fasting								
1	14.34	12.34	0.86	39.17	68	16	14	86
Pendant le jeûne — During fasting								
2	16.26	11.35	0.70	41.11	68	18	14	86
4	15.19	11.03	0.73	40.56	80	20	17	83
6	13.43	9.57	0.71	35.79	74	18	17	83
8	13.53	9.34	0.69	35.14	—	—	17	83
10	12.00	8.81	0.73	32.53	84	18	19	81
12	12.13	9.48	0.78	33.49	80	16	19	81
14	11.96	8.71	0.73	32.75	76	17	20	80
16	12.16	8.83	0.72	33.63	—	18	17	83
18	12.33	9.04	0.73	34.76	78	18	16	84
20	10.95	8.65	0.79	30.97	76	18	16	84
22	11.26	8.95	0.79	32.23	78	18	16	84
24	10.27	8.37	0.81	29.53	66	16	18	82
26	10.24	8.24	0.80	28.69	78	18	18	82
Après le jeûne — After fasting								
2	8.65	7.86	0.91	25.94	60	16	12	88
5	8.93	9.36	1.04	26.12	52	18	17	83
6	10.09	9.96	0.98	28.07	57	16	15	85
8	13.75	13.14	0.96	38.86	70	16	14	86

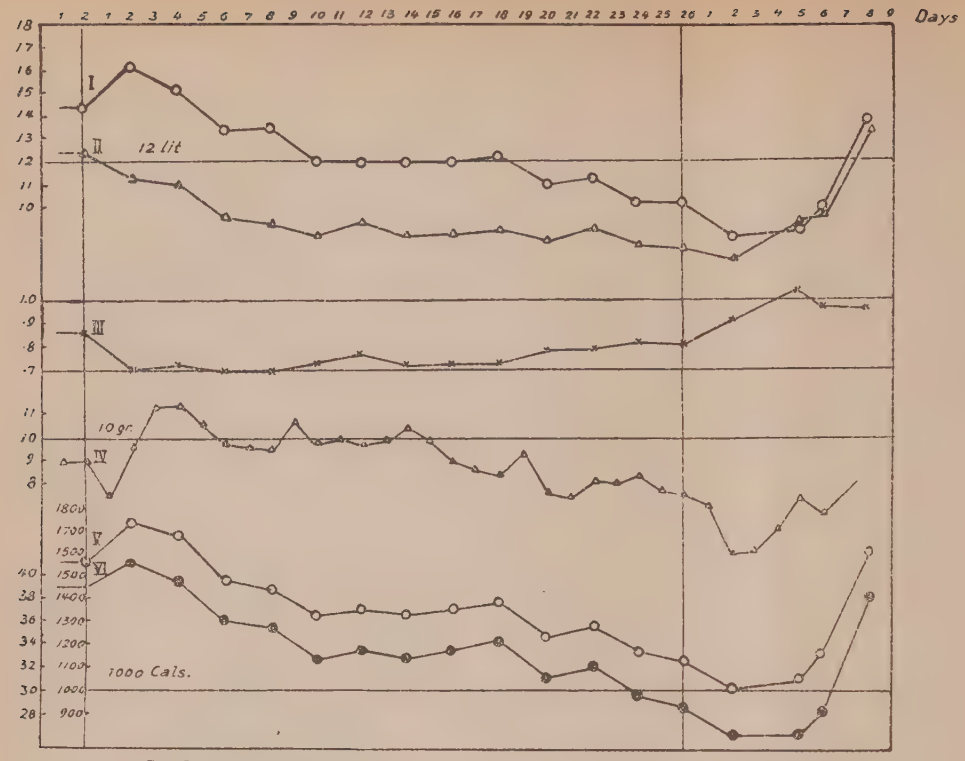
Table 7. — METABOLISM OF TAKAGOROMO.

Jour de l'expérience Day of experiment	Consommation de O^2 pr heure O_2 consumption per hour (l.)	Production de CO^2 par heure CO_2 production per hour (l.)	R.Q.	Calories par m^2 et par heure Calories per sq. m. per hour	Pouls Pulse rate	Respiration Respiration rate	Cal. d'orig. protéique Protein calories %	Autres cal. Non-protein calories %
Avant le jeûne — Before fasting								
1	13.40	10.85	0.81	38.28	60	15	15	85
Pendant le jeûne — During fasting								
2	13.60	10.55	0.78	38.63	58	14	17	83
4	11.12	8.69	0.78	31.95	58	16	22	78
6	10.58	7.98	0.75	30.62	—	14	24	76
8	11.02	8.12	0.74	32.09	—	17	20	80
10	9.68	7.75	0.80	28.61	64	16	20	80
12	9.65	7.68	0.79	28.96	73	17	19	81
14	9.57	7.40	0.77	28.98	60	16	15	85
16	8.91	7.38	0.82	27.35	64	14	18	82
18	9.05	7.50	0.82	27.94	64	14	18	82
20	8.62	7.29	0.85	27.40	62	15	19	81
22	8.64	7.53	0.87	27.05	60	15	20	80
24	8.01	7.46	0.93	25.42	63	15	20	80
26	8.24	7.44	0.90	26.15	—	15	23	77
28	8.02	7.20	0.90	25.66	64	16	25	75
30	8.09	7.24	0.89	25.97	68	16	23	77
Après le jeûne — After fasting								
2	6.87	7.38	1.07	23.07	70	16	15	85
4	7.18	7.33	1.02	24.12	63	16	15	85
7	8.07	7.96	0.99	26.02	54	15	16	84
9	8.97	9.48	1.06	28.31	56	15	16	84
11	9.97	9.82	1.00	30.72	50	12	22	78
13	10.08	10.56	1.04	29.67	50	15	20	80
19	12.11	12.22	1.09	38.23	64	16	21	79
21	14.09	13.92	0.06	43.35	68	14	18	82

Table 8. — Basal Metabolism.

Jours Days	Takahira	Shigeta	Yamana	Ito	Takagoromo
Avant le jeûne — Before fasting					
1	37.66	38.74	37.60	39.19	38.28
Pendant le jeûne — During fasting					
2	40.50	36.35	37.71	41.11	38.63
4	39.12	39.14	33.76	40.56	31.95
6	31.82	38.31	38.36	35.79	30.62
8	31.76	35.95	35.98	35.14	32.09
10	31.83	33.85	33.85	32.53	28.61
12	30.45	33.74	32.73	33.49	28.96
14		32.03	33.26	32.75	28.98
16		30.09	31.54	33.63	27.35
18			32.16	34.76	27.94
20			28.28	30.97	27.40
22				32.23	27.05
24				29.53	25.42
26				28.69	26.15
28					25.66
30					25.97
Après le jeûne — After fasting					
2	24.11	32.22	27.35	25.94	23.07
4	26.63	37.44	22.67	26.12	24.12
6		32.97	25.96	28.07	26.02
8	37.69	35.67	28.51	38.86	28.31
10					30.72
11	41.30				
13					29.67
19					38.23
21					43.35

Chart 2. — Metabolism of Ito.



I. O_2 consumption.
II. CO_2 production.
III. R.Q.
IV. N excretion.
V. Total calories.
VI. Number of calories per sq. m.

In the first few days of re-feeding after the fast, the basal metabolism is very low, even lower than on the last fast day. This may be due to decreased protein catabolism and to the occurrence of œdema in the tissues. Later the metabolism again increases to its normal value and finally exceeds it. In Takahira it had risen to 41.30 calories by the 11th day after the fast; in Takagoromo it had reached 43.35 calories by the 21st day after the fast.

4. Nature of the Substances catabolised in the Body.

The nature of the substances catabolised in the body can be judged by the respiratory quotient and the nitrogen excretion in the urine. However, the gross respiratory quotient must be regarded as the resultant of many factors, so that, from a purely mathematical consideration of the respiratory quotient, one may fail to grasp its biological significance.

The respiratory quotient becomes lower in the fasting period, being below 0.8. It is usually lowest after the first week's fast, when it becomes nearly 0.7. This suggests that the chief combustible material of the body is fat. During the fasting period, when a large amount of acetone bodies are being excreted in the urine, the respiratory quotient decreases. After this period it again increases slightly.

During the time of re-feeding, the respiratory quotient rose and often reached 1.0. This was a very curious phenomenon; if it were not due to the excessive pumping out of carbon dioxide from the blood, it may signify that carbohydrate was being chiefly burned or that fat was being formed from carbohydrate.

The excretion of nitrogen in the urine decreased during the first fasting day. This was due to the sparing action of glycogen, which was being burned in the body. During the second day the nitrogen excretion increased again and the maximum excretion was reached on the 3rd or 4th fasting day. After this time the nitrogen excretion decreased slowly and remained fairly constant; in Ito, the nitrogen excretion decreased steadily till the end of the fast.

Table 9. — Nitrogen Excretion Before, During and After Fasting.

Jours Days	Takahira	Shigeta	Yamana	Ito	Takagoromo
Avant le jeûne — Before fasting					
1	10.116	7.897		8.926	9.226
2	10.286	7.967	7.157	8.813	9.036
Pendant le jeûne — During fasting					
1	8.302	7.145	* 7.322	7.594	8.741
2	10.399	8.153	* 6.506	9.646	9.922
3	12.057	12.027	* 5.976	11.289	12.275
4	11.470	12.587	* 6.453	11.346	10.598
5	10.796	11.735	* 7.513	10.796	10.399
6	11.289	11.308	* 8.419	9.918	10.683
7	11.879	10.290	10.872	9.548	9.719
8	10.889	10.535	10.610	9.493	9.521
9	10.683	10.762	11.114	10.896	8.954
10	11.177	10.726	10.960	9.889	8.331
11	10.904	11.761	10.003	10.172	8.259
12	10.739	11.096	8.756	9.833	8.076
13		10.712	8.302	9.918	7.396
14		11.416	8.869	10.456	6.376
15		10.663	8.557	9.926	6.886
16		10.336	8.413	8.868	7.226
17			7.981	8.699	7.159
18			8.227	8.444	7.141
19			8.037	9.379	7.197
20			8.812	7.679	7.367
21			8.302	7.339	6.509
22			8.596	8.144	7.396
23			7.952	8.019	8.076
24				8.274	7.991
25				7.736	8.586
26				7.537	8.216
27					8.926
28					8.677
29					8.436
30					7.977

* Diète progressive. — Decreased diet.

Table 9. — Nitrogen Excretion Before, During and After Fasting *(cont.)*

Jours Days	Takahira	Shigeta	Yamana	Ito	Takagoromo
Après le jeûne — After fasting					
1	15.018	9.704	6.489	7.056	6.489
2	18.090	9.479	5.242	4.817	4.959
3	25.270	6.594	5.806	5.086	4.619
4	18.648	5.876	6.469	6.319	4.874
5	21.847	6.364	7.024	7.248	6.829
6	17.098	7.877	6.271	6.631	6.206
7	19.949	9.375	7.962		6.036
8	20.689	15.205			5.044
9	19.228				6.602
10	19.268				7.789

The amount of nitrogen excreted per kilogram during the fast differed considerably in each subject. It was greater in the thin men and smaller in Ito.

	Excretion of N. (average per day per kilo)
Takahira	0.2402 gram
Shigeta	0.2780 »
Yamana	0.2046 »
Ito	0.1334 »
Takagoromo	0.1674 »

During the subsequent re-feeding the nitrogen excretion decreased and reached a minimum value after a few days. This minimum nitrogen excretion per kilogram of body weight was as follows:

Shigeta	0.1623 gram
Yamana	0.1257 »
Ito	0.0740 »
Takagoromo	0.1024 »

This minimum value did not occur if foods rich in protein were taken as they were by Takahira.

By mathematical computation, the nature of the catabolism during the fast was determined with the following results:

	Protein calories %	Non-protein calories %
Takahira	23	77
Shigeta	33	67
Yamana	19	81
Ito	17	83
Takagoromo	20	80

The percentage of protein catabolism varied from 17 to 33; it was greater in the thin men and less in Ito. The non-protein portion of the catabolism chiefly concerned fats. However, the non-protein respiratory quotient did not designate pure fat combustion; it is possible that carbohydrate combustion was going on as well.

It is a well-known fact that, during fasting, the blood sugar does not disappear; nor does the liver glycogen wholly disappear. Even though glycogen is burned during the first few days of fasting, it may be again resynthesised from fat or protein. There are two possible modes of derivation of carbohydrate from fat; it may be built up either from glycerine or from fatty acid radicals. Ringer and Lusk demonstrated beyond any doubt the possibility of the formation of sugar from such amino-acids as glycocoll and alanin and also from glutamic and aspartic acids. The need for carbohydrates is so great that the organism unable to obtain them with its food uses every available method to satisfy this nereod.

5. Subsequent Re-feeding.

Soon after the fasting and during the subsequent re-feeding the basal metabolism was still low, but after a few days it greatly increased. The metabolism in Takahira had reached 41.30 calories by the 10th day of re-feeding, and in Takagoromo 43.35 calories by the 21st day of re-feeding. The body temperature during the period of re-feeding was slightly higher than before fasting.

The nitrogen balance during the re-feeding period gave remarkable figures. In Takagoromo, during the 5th to the 10th days of the re-feeding period, a daily intake of 10 to 14 grams of nitrogen gave an average retention of 4.75 grams. With abundant nitrogen feeding, Takahira, during the 12 days of the re-feeding period, retained an average of 6.11 grams of nitrogen daily.

Table 10. — Nitrogen Balance of Takagoromo.

Jour de l'expérience Day of experiment	N. absorbé N. intake	N. éliminé N. output		Gain ou perte Balance	Nombre de calories dans la nourriture Calories in food
		dans l'urine In urine	dans les selles In fæces		
Avant le jeûne — Before fasting					
1	12.350	9.226	3.111	+ 0.013	2348
2	12.350	9.036	3.433	— 0.119	2348
Après le jeûne — After fasting					
1	0.016	6.489	0.512	— 6.985	413
2	2.577	4.959	0.512	— 2.895	876
3	3.681	4.619	0.468	— 1.406	919
4	4.237	4.874	1.001	— 1.638	777
5	10.068	6.829	2.018	+ 1.221	1886
6	10.003	6.206	1.630	+ 2.167	1804
7	11.932	6.036	1.254	+ 4.642	2250
8	14.910	5.044	3.107	+ 6.759	2643
9	14.277	6.602	3.608	+ 4.067	2871
10	14.321	7.789	2.997	+ 3.535	2933

Table 11. — Nitrogen Balance of Takahira.

Jour de l'expérience Day of experiment	N. absorbé N. intake	N. éliminé N. output		Gain ou perte Balance	Nombre de calories dans la nourriture Calories in food
		dans l'urine In urine	dans les selles In fæces		
Avant le jeûne — Before fasting					
1	12.204	10.116	2.755	— 0.668	2327
2	12.204	10.286	2.613	— 0.696	2327
Après le jeûne — After fasting					
1	13.778	15.018	2.135	— 3.375	2080
2	22.162	18.090	1.298	+ 2.774	2378
3	36.408	25.270	2.712	+ 8.526	2950
4	26.745	18.648	1.521	+ 6.686	2171
5	33.004	21.847	2.735	+ 8.422	2518
6	26.977	17.098	2.601	+ 7.278	2610
7	30.520	19.949	2.366	+ 8.205	4165
8	31.513	20.689	2.104	+ 8.720	4605
9	32.786	19.228	2.769	+10.789	3620
10	30.911	19.268	3.589	+ 8.066	3652
11	29.521	21.139	3.269	+ 5.113	3162
12	28.454	22.020	3.269	+ 3.165	2832

The body weight of the subjects increased steadily and in 60 to 100 days it reached a maximum. After this time the weight tended to decrease again. In the very obese man Ito, the body weight did not exceed its normal value during the re-feeding period.

Child and Morgulis discovered that in salamanders and in white rats a rejuvenescence occurs in the tissues during recovery from fasting. The energy exchange, nitrogen balance and body weight changes in our men agree with his findings.

Table 12. — Change of Body Weight after Fasting.

(Body Weight in kgs.)

Takahira		Takahira		Shigeta		Yamana		Ito		Takagoromo	
Jours Days	Poids Weight	Jours Days	Poids Weight	Jours Days	Poids Weight	Jours Days	Poids Weight	Jours Days	Poids Weight	Jours Days	Poids Weight
Avant le jeûne. — Before fasting.											
1	50.50			1	43.60			1	77.70	1	58.70
2	50.20	1	50.50	2	43.30	1	50.55	2	77.10	2	58.85
Après le jeûne. — After fasting.											
1	42.60	1	42.20	1	36.00	1	41.35	1	64.40	1	44.95
2	42.90	2	43.90	2	35.50	2	40.90	2	65.10	2	44.95
3	45.90	3	45.80	3	35.40	3	41.10	3	67.50	3	45.10
4	48.40	4	47.00	4	36.20	4	41.90	4	69.40	4	44.85
5	49.20	5	48.40	5	37.10	5	42.10	5	70.25	5	45.45
6	49.70	6	48.60	6	37.70	6	43.60	6	70.65	6	46.40
7	49.70	7	50.00	7	38.90	7	44.60	7	70.60	7	47.55
8	49.90	8	50.00	8	40.30	8	45.00	17	73.10	8	48.80
9	51.00	9	49.40	32	45.00	9	46.30	47	75.95	9	50.50
10	50.40	11	51.20	45	46.30	10	47.30	54	75.75	10	51.45
11	51.00	12	50.80	74	46.50	25	50.50	91	76.00	11	52.00
12	50.90	13	50.40	139	48.00	49	55.60	103	76.50	12	53.30
22	52.20	14	50.20	530	49.30	70	56.60	355	81.37	13	53.90
32	54.10	20	52.60			107	57.70			14	53.90
42	55.50	25	53.80			114	57.00			15	54.15
52	56.00	31	54.30							16	53.95
60	56.00	36	54.20							17	51.70
75	55.10	47	55.50							18	52.50
87	55.00	50	54.20							19	52.30
120	54.00	55	54.50							20	52.75
150	54.00	61	54.10							21	53.60
181	52.20	65	54.60							22	54.30
		102	53.20							23	53.60
										35	58.40
										43	60.60
										51	61.50
										69	62.00
										85	62.20
										385	62.00

Table 13. — Change of Body Weight after Fasting.

(Body Weight in percentages.)

Takahira		Takahira		Shigeta		Yamana		Ito		Takagoromo	
Jours Days	Poids Weight	Jours Days	Poids Weight	Jours Days	Poids Weight	Jours Days	Poids Weight	Jours Days	Poids Weight	Jours Days	Poids Weight
Avant le jeûne. — Before fasting.											
1	100.2			1	100.2			1	100.6	1	100.8
2	99.6	1	102.2	2	99.5	1	99.4	2	99.9	2	100.5
Après le jeûne. — After fasting.											
1	84.5	1	85.4	1	82.8	1	81.3	1	83.4	1	77.0
2	85.1	2	88.9	2	81.6	2	80.4	2	84.3	2	77.0
3	91.1	3	92.7	3	81.4	3	80.8	3	87.4	3	77.2
4	96.0	4	95.1	4	83.2	4	82.4	4	89.9	4	76.8
5	97.6	5	98.0	5	85.3	5	82.8	5	91.0	5	77.8
6	98.6	6	98.4	6	86.7	6	85.7	6	91.5	6	79.5
7	98.2	7	101.2	7	89.4	7	87.7	7	91.5	7	81.4
8	99.0	8	101.2	8	92.6	8	88.5	17	94.7	8	83.6
9	101.1	9	100.0	32	103.4	9	91.1	47	98.4	9	86.5
10	100.0	10	103.6	45	106.4	10	93.0	54	98.1	10	88.1
11	101.1	12	102.8	74	106.9	25	99.3	91	98.3	11	89.0
12	101.0	13	102.0	139	110.3	49	109.3	103	99.1	12	91.3
22	103.6	14	101.6	530	113.3	70	111.1	355	105.3	13	92.3
32	107.3	20	106.5			107	113.5			14	92.3
42	110.1	25	109.9			114	112.9			15	92.7
52	111.1	31	109.2							16	92.0
60	111.1	36	109.7							17	88.5
75	109.3	47	102.3							18	89.9
87	109.1	50	109.5							19	89.6
120	107.1	55	110.3							20	90.3
150	107.1	61	109.5							21	90.0
181	103.6	65	110.5							22	92.9
		102	107.5							23	90.0
										35	100.0
										43	103.8
										51	105.3
										69	106.2
										85	106.5
										385	106.2

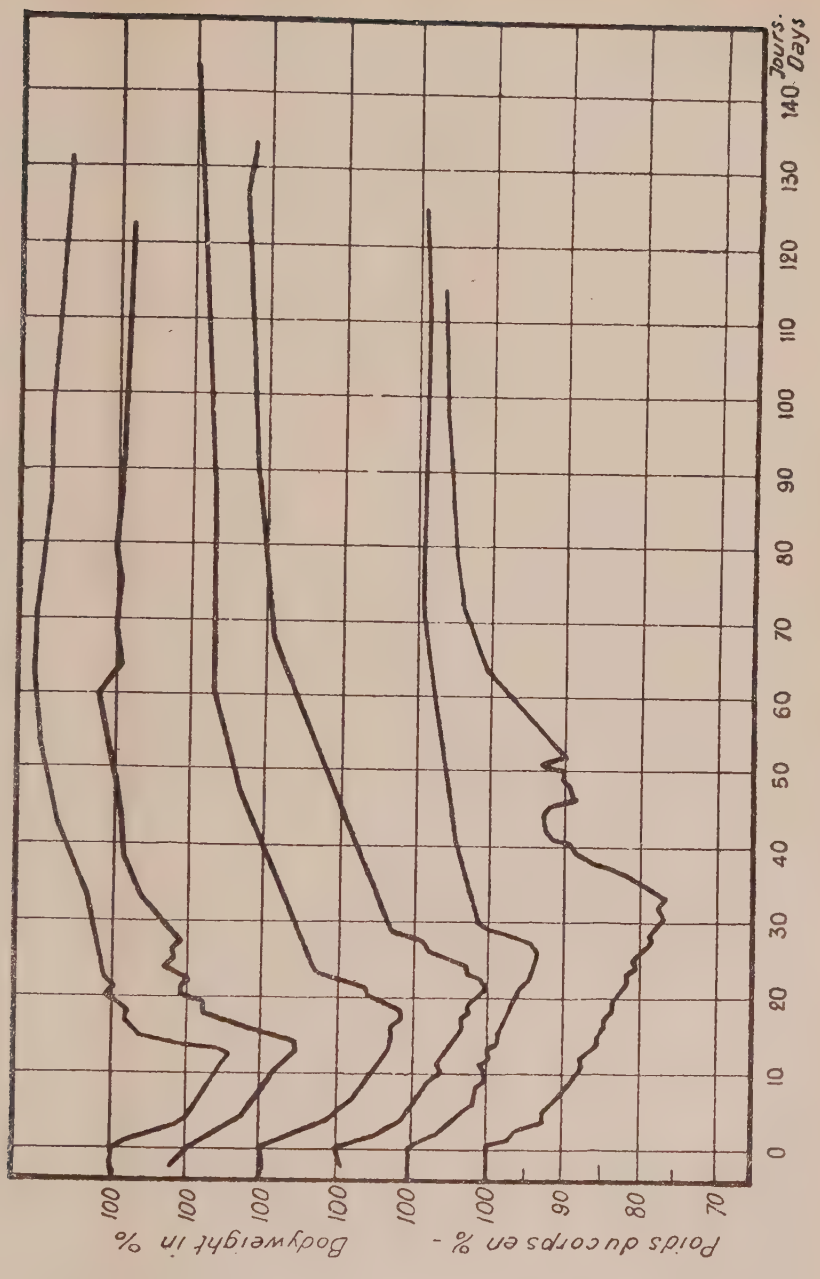


Chart 3. — Change of Body-weight after Fasting.

6. Summary.

Six men fasted for 12 to 30 days. Their loss of body weight was shown by means of a curve.

The decrease in the basal metabolism to the physiological minimum during the fasting period and the nature of the substances catabolised in the body have been discussed.

During the subsequent re-feeding after fasting there was a tendency to retain a large amount of nitrogen. The basal metabolism increased above the normal value. The body weight exceeded the normal 80 to 100 days after the beginning of the re-feeding period.

6.

IMPROVEMENT OF THE PHYSICAL CONDITION OF MALNOURISHED CHILDREN.

By T. Kawakami and C. Takanabe

(From the Imperial State Institute for Nutrition, Tokyo).

Under the direction of Dr. Tadasu Saiki, we investigated the improvement of the physical condition of weak children brought about by diet.

503 malnourished children (285 males and 218 females) of 8 to 15 years old were kept in hospital and observed for three weeks. Special attention was paid to their diet during the period of observation. The following points were observed: (1) the relationship between increase or decrease of the body weight and the amount of food consumed; (2) the relationship between the ages of the children and the amount of food consumed; (3) the relationship between constancy of body weight and the amount of food consumed.

The results are shown in the following tables:

Table I. — Relationship between Increase or Decrease of Body Weight and the Amount of Food Taken.

			Nombre d'enfants Number of children	Quantité moyenne d'aliments par enfant et par jour Average amount of food taken by a child per day		Quantité moyenne d'aliments par kilogr. et par jour Average amount of food taken per 1 kg. body weight per day	
				Protéïne Protein	Calories	Protéïne Protein	Calories
(a) *Garçons — Boys.*		Ont perdu du poids Decrease in body-weight	18	67.4	1834	2.91	77.4
Nombre total des enfants du sexe masculin observés Total number of male children under examination	285	Sont restés stationnaires Steadiness of body-weight	11	65.9	1827	2.83	78.2
		Ont augmenté de poids Increase in body-weight — De 0 à 500 gr. 0 to 500 gms.	100	70.2	1941	3.02	83.0
		Ont augmenté de poids Increase in body-weight — De 500 à 1000 gr. 500 to 1000 gms.	91	69.9	1910	3.20	84.8
		Ont augmenté de poids Increase in body-weight — De 1000 à 1500 gr. 1000 to 1500 gms.	41	69.3	1966	3.01	85.8
		Ont augmenté de poids Increase in body-weight — De plus de 1500 gr Over 1500 gms.	24	71.3	2069	3.01	86.8
(b) *Filles — Girls.*							
Nombre total des enfants du sexe féminin observés Total number of female children under examination	218	Ont perdu du poids Decrease in body-weight	6	65.0	1745	2.51	65.5
		Sont restés-stationnaires Steadiness of body-weight	12	64.2	1684	2.72	69.3
		Ont augmenté de poids Increase in body-weight — De 0 à 500 gr. 0 to 500 gms.	57	62.8	1656	2.81	76.0
		Ont augmenté de poids Increase in body-weight — De 500 à 1000 gr. 500 to 1000 gms.	86	64.9	1736	2.91	77.6
		Ont augmenté de poids Increase in body-weight — De 1000 à 1500 gr. 1000 to 1500 gms.	44	64.8	1794	2.98	81.5
		Ont augmenté de poids Increase in body-weight — De plus de 1500 gr. Over 1500 gms.	13	68.8	1906	3.24	88.9

As shown in the above table, increase of the body-weight and of the consumption of food run parallel.

Table II. — Relationship between the Ages and the Amount of Food taken.

Age	Nombre d'enfants Number of children	Poids moyen Average body weight	Taille moyenne Average height	Quantité moyenne de nourriture absorbée par enfant et par jour Average amount of food taken by a child per day		Quantité de nourriture absorbée par kilog et par jour Amount of food taken per 1 kg. body. weight per day	
				Protéine gr. Protein gms.	Calories	Protéine gr. Protein gms.	Calories
Ans Years				(a) *Garçons — Boys*			
8	10	19.720	115.7	66.2	1818	3.36	92.3
9	39	20.200	117.3	65.9	1778	3.25	88.3
10	85	21.430	121.8	64.7	1810	3.06	83.4
11	66	23.830	123.7	70.0	1943	2.97	81.1
12	55	25.050	131.2	74.2	1959	2.96	78.2
13	15	27.830	134.8	74.8	2129	2.69	76.4
14	7	29.250	136.4	76.8	2166	2.63	37.9
				(b) *Filles — Girls*			
8	88	18.520	115.2	62.9	1641	3.40	88.5
9	32	20.240	120.6	64.2	1679	3.09	85.2
10	64	27.000	121.9	64.3	1673	3.08	81.5
11	75	23.230	124.5	64.3	1737	2.73	75.8
12	46	52.300	130.7	66.8	1812	2.64	71.6
13	9	25.460	130.2	68.7	1917	2.75	73.9
14	3	30.290	141.1	64.1	1805	2.13	59.2

As shown in the above table, the total amount of food taken by children increases with age; on the other hand, the amount of food taken per kilogram of body weight decreases with age.

Table III. — Relationship between the Steadiness of Body-weight and the Amount of Food taken.

Poids Body-weight	Nombre d'enfants Number of children	Quantité moyenne de nourriture absorbée par enfant et par jour Average amount of food taken by a child per day		Quantité de nourriture absorbée par kilogramme de poids. Amount of food taken per 1 kg. body-weight	
		Protéine (gr.) Protein (gms.)	Calories	Protéine (gr.) Protein (gms.)	Calories
		(a) *Garçons — Boys.*			
Environ – Around 20 kg.	23	66.7	1854	3.26	90.3
25 »	14	72.6	1968	2.85	77.4
30–31 »	6	73.5	2108	2.39	68.7
		(b) *Filles — Girls.*			
Environ – Around 20 kg.	29	63.7	1703	3.20	83.5
25 »	13	68.3	1838	2.69	72.5
30–31 »	5	70.7	1969	2.28	64.6

The total amount of food taken runs parallel to the body weight but the amount of food taken per kilogram body weight per day decreases with the increase of body weight.

As shown by the results obtained, we were able to improve the malnourished children by proper diet within 3 weeks. We wish therefore to propose a standard diet for malnourished and weak Japanese children, which is as follows:

Age	Poids Body-weight (Kilog.)	Quantité de nourriture par jour Amount of food per day		Quantité de nourriture par kilog. de poids Amount of food per 1 kilog. of body-weight	
		Protéine (gr.) Protein (gms.)	Calories	Protéine (gr.) Protein (gms.)	Calories
(a) *Garçons — Boys.*					
8 ans — years	19.500	65.0	1800	3.4	92.8
9 »	20.500	65.0	1830	3.1	89.3
10 »	22.000	65.0	1880	2.09	85.5
11 »	23.500	70.0	1940	2.7	82.6
12 »	25.500	70.0	1980	2.6	78.0
13 »	28.500	75.0	2120	2.5	75.7
14 »	30.000	75.0	2200	2.3	73.3
(b) *Filles — Girls.*					
8 ans — years	18.500	63.0	1650	3.4	89.2
9 »	20.000	65.0	1700	3.1	87.0
10 »	21.000	65.0	1750	3.0	82.9
11 »	23.500	65.0	1800	2.7	78.3
12 »	25.500	70.0	1850	2.6	74.5
13 »	27.000	70.0	1900	2.5	72.3
14 »	30.000	70.0	2100	2.3	70.1

7.

STUDIES ON THE DIGESTIBILITY AND UTILISATION OF RICE OF DIFFERENT GRADES OF POLISHING.

By Koichi Sugimoto

(From the Imperial State Institute for Nutrition, Tokyo).

FIRST REPORT.

A general summary of this paper was reported at the third and fourth meetings of the Imperial Government Institute for Nutrition, at the second meeting of the Physiological Association of Japan, and at the combined meeting of the Japanese Agricultural and the Japanese Agricultural Chemical Association, held in April 1925.

Introduction.

Rice is the staple food of the Japanese, so that the investigation of problems connected with its use is most important and necessary, not only from the scientific standpoint but also from that of Japanese national economy and food policy.

Rice was used in Japan for centuries in its crude form. About two hundred years ago, in Tokugawa's era, the Japanese began to eat polished rice and since then its use has gradually became universal in the country.

Numerous studies and investigations concerning the effect of polishing rice have recently been carried out, especially since the discovery of vitamins and of their relation to beri-beri. The problem is not yet settled and many different points remain to be investigated.

When the Imperial State Institute for Nutrition was founded under the direction of T. Saiki, I started experiments on the digestibility and utilisation of rice of different grades of polishing to ascertain what grade of polishing we should recommend for our national food.

There are numerous papers dealing with the digestibility of foods containing rice as the staple constituent, yet most of the work reported has been concerned with polished rice. We have found very few papers dealing with the comparative digestibility of rice of different grades of polishing. Experiments undertaken to compare the digestibility of unpolished and half-polished rice have already been carried out, but under such unsatisfactory and varying conditions that the results obtained are not comparable.

Methods of Procedure.

The experiments were carried out on men living under conditions of ordinary daily life. During the experiments they resided at the Institute and engaged in their regular routine work. They were examined medically every day and careful attention was paid to their health. They were weighed each morning just before breakfast.

Each experiment lasted for 13 days; the first three days I shall call the "preparatory period", the last two days the "latter period", and the eight days in between the "principal experimental period". This last period was divided into four periods of two days each, called respectively the "polished rice period", the "half-polished rice period", the "70%-polished rice period", and the "unpolished rice period"; during each period the subjects were given rice of the polishing grade corresponding to the respective periods. In the preparatory and latter periods they took the same polished rice as in the polished rice period. During the experiment their temperatures were taken every day.

The rice used for the experiment was third-grade "Shonai", which is commonly used by the Japanese. This rice was polished at the Institute without the use of "polishing powder". The percentage lost by polishing was 7.26 per cent in polished rice, 5.47 per cent in 70%-polished rice, and 4.19 per cent in half-polished rice.

The rice was cooked before each meal. One "sho" (1.82 litre) of rice was repeatedly washed until the wash water was almost clear (as is commonly practised in Japanese households) and was then cooked. The volume of water used for cooking the rice depended upon the grade of polishing of the rice; the amount of water was 2,000 cc. for polished rice, 2,300 cc. for 70%-polished rice and half-polished rice, and 3,000 cc. for unpolished rice. Analysis of the boiled rice of the different grades of polishing gave the following results:

	Total N. %	Crude protein %	Carbo-hydrate as glucose %	Crude fat %	Crude ash %	Water %
Polished rice . . .	0.3868	2.41	30.29	0.25	0.12	66.07
70%-polished rice .	0.4697	2.94	30.37	0.45	0.18	63.63
Half-polished rice. .	0.4940	3.09	27.97	0.50	0.23	62.71
Unpolished rice . .	0.5320	3.31	30.97	1.12	0.48	58.95

The side dishes eaten by each subject were kept constant throughout the experiment, while the boiled rice and drinking-water were taken *ad libitum*. The side dishes were cooked in the same way at each meal time, each item being accurately weighed or measured.

The constituents of the daily side dishes were as follows:

Repas Meal	Aliments Materials	Quantité (gr.) Quantity (gms.)	Azote total (gr.) Total N. (gms.)	Protéine brute (gr.) Crude protein (gms.)	Hydrocarbures glycose (gr.) Carbohydrate as glucose (gms.)	Graisse brute (gr.) Crude fat (gms.)	Cendres brutes (gr.) Crude ash (gms.)	Calories
Matin — Morning	Miso	38	0.4451		3.18	1.77	3.19	
	Satoimo	100	0.3110		13.44	0.18	0.93	
	Poisson sec en poudre Dried fish powder	3	0.3336			0.19	0.67	
	Takuwan	40	0.0976		2.42	0.14	2.03	
	Total		1.1873	7.4206	19.04	2.28	6.82	129.692
Midi — Noon	Sardines (grillées) Sardine (broiled)	50	2.8675			4.35	5.18	
	Pommes de terre (frites) Potato (fried)	70	0.2284		11.75	5.37	0.83	
	Daikon	30	0.0250		0.31	0.04	0.08	
	Takuwan	30	0.0732		1.81	0.10	1.52	
	Total		3.1941	19.9631	13.87	9.86	7.61	230.413
Soir — Evening	Daikon	50	0.0417		0.51	0.07	0.14	
	Tofu frit Fried Tofu	20	0.4933			6.07	0.19	
	Oignon Onion	20	0.0360		1.39	0.06	0.11	
	Poisson sec en poudre Dried fish powder	2	0.2224			0.12	0.45	
	Shoyu	25 cc.	0.3642		1.39		4.63	
	Oignon Onion	100	0.1800		6.95	0.29	0.56	
	Tofu	60	0.5961		0.02	3.34	0.36	
	Miso	38	0.4451		3.18	1.77	3.19	
	Vinaigre Vinegar	40 cc.						
	Sucre Sugar	15			14.85			
	Takuwan	30	0.0732		1.81	0.10	1.52	
	Total		2.4520	15.3250	30.10	11.82	11.15	296.169
	Total journalier Daily total		6.8334	42.7087	63.01	23.96	25.58	656.274

Note: Miso: Sorte de pâte de haricots.
Tofu: est la protéïne coagulée des fèves de soy.
Satoimo: Variété de pomme de terre chinoise.
Shoyu: est une sauce salée préparée avec des fèves de soy.
Daikon: Variété de radis japonais.
Takuwan: Daikon mariné.

Note: Miso is a kind of bean paste.
Tofu is the protein curd of soy beans.
Sato mo is a kind of Chinese potato,
Shoyu is a salty sauce made from soy beans.
Daikon is a kind of Japanese radish.
Takuwan is pickled Daikon.

The whole of the urine passed during each 24-hour period was collected. After the volume, specific gravity and reaction of the urine had been taken, the urine was diluted to 2,000 cc. with distilled water to facilitate its analysis. To preserve the sample, a small quantity of toluene was added.

In order that the fæces corresponding to the foods ingested in each period might be recognised, 0.5 gms. of carmine (Merk) or the same quantity of *carbo sanguinis* (Merk) was given to the subject before breakfast.

The methods of analysis and the mode of calculation of the digestibility were those commonly employed in metabolic experiments. The difference between the quantity of food ingested and the quantity excreted in the fæces was considered as the quantity digested. The digestibility was represented as a percentage calculated from the quantity absorbed. It is possible, of course, to calculate the balance of total nitrogen from determinations of the total nitrogen in the urine. It is very difficult to investigate the metabolism of carbohydrate or fat by determining merely the quantity present in the fæces; for this purpose it is advisable to make observations by means of the respiratory calorimeter. This is being carried on in another department under Director Saiki.

The following results were obtained:

Balance of Total Nitrogen, its Digestibility and Caloric Value of the Utilised Protein.

Sujets / Subject	Période / Period	Absorption journalière moyenne d'azote — N. intake Average per day: Azote total (gr.) Total nitrogen (gms.)	Absorption journalière moyenne d'azote — N. intake Average per day: Protéine brute (gr.) Crude protein (gms.)	Elimination journalière moyenne d'azote — N. output Average per day: Azote dans l'urine (gr.) N. in urine (gms.)	Elimination journalière moyenne d'azote — N. output Average per day: Azote dans les selles (gr.) N. in fæces (gms.)	Equilibre azoté / Nitrogen Balance	Absorption moyenne par jour — Absorption Average per day: Azote (gr.) Nitrogen (gms.)	Absorption moyenne par jour — Absorption Average per day: Protéïne (gr.) Protein (gms.)	Absorption moyenne par jour — Absorption Average per day: Calories	Pourcentage d'absorption / % of absorption
Higuchi	Période préparatoire / Preparatory period	11.4639	71.6493	10.6745	2.5020	— 1.7126	8.9619	56.0119	229.649	78.18
	Riz glacé / Polished rice	11.5479	72.1743	10.6015	1.1858	— 0.2394	10.3621	64.7631	265.529	89.73
	Riz mi-glacé / Half-pol. rice	12.8343	80.2143	10.8866	3.4222	— 1.4745	9.4121	58.8256	241.185	73.34
	Riz glacé à 70 % / 70% pol. rice	12.5427	78.3918	10.9576	2.8958	— 1.3107	9.6469	60.2931	247.202	76.91
	Riz non glacé / Unpolished rice	9.4169	58.8549	9.8618	2.9811	— 3.4260	6.4358	40.2238	164.918	68.34
	Après / Latter	11.5479	72.1743	11.6466	2.0849	— 2.1836	9.4630	59.1438	242.490	81.95
Momoyeda	*Idem*	12.5863	78.6643	9.0309	2.4651	+ 1.0903	10.1212	63.2575	259.356	80.42
		12.7811	79.8818	10.2180	1.2536	+ 1.3095	11.5275	72.0469	295.392	90.19
		13.1541	82.2131	10.2591	2.5457	+ 0.3493	10.6084	66.3025	271.840	80.65
		14.0246	87.6537	10.3225	2.5751	+ 1.1270	11.4495	71.5594	293.375	81.64
		11.2351	70.2193	10.8750	2.9131	— 2.5530	8.3222	52.0138	213.257	74.06
		12.7811	79.8818	11.8472	1.0863	— 0.1524	11.6949	73.0931	299.682	91.50
Sugisaki	*Idem*	11.6207	72.6293	10.2532	1.7513	— 0.3838	9.8694	61.6838	252.804	84.93
		12.2009	76.2556	11.1768	1.6995	— 0.6754	10.5014	65.6338	269.099	86.07
		12.9071	80.6693	11.5814	2.4951	— 1.1694	10.4120	65.0750	266.808	80.67
		13.9398	87.1237	11.8886	2.3613	— 0.3101	11.5785	72.3656	296 699	83.06
		9.7721	61.0756	11.4781	3.4038	— 5.1098	6.3683	39.8019	163.188	65.17
		12.3943	77.4643	11.6520	2.2955	— 1.5532	10.0988	63.1175	258.782	81.48

Digestibility and Utilised Calories of Carbohydrate.

Sujets Subject	Période Period	Absorption journalière moyenne des hydr. de carbone (gr.) Carbohydrate intake Average per day (gms.)	Moyenne journalière des hydr. de carbone trouvés d. les selles (gr.) Carbohydrate in fæces Average per day (gms.)	Moyenne d'absorption journalière Absorption Average per day		Pourcentage d'absorption % of absorption
				Quantité (gr.) Quantity (gms.)	Calories	
Higuchi	Période préparatoire Preparatory period	421.61	1.7121	419.90	1721.590	99.59
	Riz glacé Polished rice	426.76	1.4095	425.35	1743.935	99.67
	Riz mi-glacé Half-pol. rice	398.92	2.5515	396.37	1625.117	99.36
	Riz glacé à 70% 70% pol. rice	427.72	4.0284	423.69	1737.129	99.06
	Riz non glacé Unpolished rice	209.46	6.8098	202.65	830.865	96.75
	Après Latter	426.76	1.8388	424.92	1742.172	99.56
Momoyeda	*Idem*	497.96	1.5299	496.43	2035.363	99.69
		517.91	1.4291	516.48	2117.568	99.72
		413.19	2.7013	410.49	1683.009	99.35
		519.11	4.1017	515.01	2111.541	99.21
		311.32	9.0704	302.25	1239.225	97.09
		517.91	1.4628	516.45	2117.445	99.72
Sugisaki	*Idem*	427.04	1.8849	425.16	1743.156	99.61
		472.48	1.8839	470.60	1929.460	99.60
		399.20	4.4592	394.74	1618.434	98.88
		503.93	3.2069	500.72	2052.952	99.36
		226.16	5.8012	220.36	903.476	97.43
		487.63	2.0916	485.54	1990.714	99.57

Digestibility and Utilised Calories of Crude Fat.

Sujets Subject	Période Period	Quantité moyenne de graisse absorbée par jour (gr.) Fat intake Average per day (gms.)	Quantité moyenne de graisse trouvée d. les selles par jour (gr.) Fat in fæces Average per day (gms.)	Absorption moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
				Quantité (gr.) Quantity (gms.)	Calories	
Higuchi .	Période préparatoire Preparatory period	26.92	3.6090	23.31	216.783	86.63
	Riz glacé . . . . Polished rice . .	26.96	2.2181	24.74	230.082	91.78
	Riz mi-glacé . . Half-pol. rice . .	29.96	5.4863	24.47	227.571	81.69
	Riz glacé à 70 % 70% pol. rice . .	29.36	4.8563	24.50	227.850	83.46
	Riz non glacé . Unpolished rice .	29.25	6.4672	22.78	211.854	77.88
	Après . . . . . Latter	26.96	2.6055	24.35	226.455	90.32
Momoyeda	*Idem*	27.54	2.9213	24.62	228.966	89.40
		27.71	2.2425	25.47	236.871	91.92
		30.21	6.0220	24.19	224.967	80.07
		30.71	4.8000	25.91	240.963	84.37
		32.92	9.7879	23.13	215.109	70.26
		27.71	2.1499	25.56	237.708	92.65
Sugisaki .	*Idem*	26.96	2.6746	24.29	225.897	90.08
		27.34	2.4259	24.91	231.663	91.13
		29.96	5.6406	24.32	226.176	81.17
		30.49	4.1037	26.39	245.427	86.54
		29.84	7.3564	22.48	209.064	75.34
		27.46	2.4430	25.02	232.686	91.11

Digestibility of Crude Ash.

Sujets Subject	Période Period	Quantité moyenne de cendres absorbées par jour (gr.) Ash intake Average per day (gms.)	Quantité moyenne de cendres trouvées dans les selles par jour (gr.) Ash in fæces Average per day (gms.)	Absorption moyenne journalière (gr.) Absorption Average per day (gms.)	Pourcentage d'absorption % of absorption
Higuchi	Période préparatoire Preparatory period	27.80	3.5594	24.24	87.20
	Riz glacé Polished rice	27.94	2.4666	25.47	91.17
	Riz mi-glacé Half-polished rice	29.26	4.3220	24.94	85.23
	Riz glacé à 70% 70% polished rice	28.66	4.4961	24.16	84.31
	Riz non glacé Unpolished rice	28.77	4.9485	23.82	82.80
	Après Latter	27.94	2.2766	25.66	91.85
Momoyeda	*Idem*	29.86	3.0561	26.80	89.73
		29.22	1.9134	27.31	93.45
		29.36	5.5763	23.78	81.01
		30.12	4.4382	25.68	85.26
		31.26	6.5010	24.76	79.20
		29.22	2.3621	26.86	91.92
Sugisaki	*Idem*	28.86	2.0686	26.79	92.83
		29.04	3.9330	25.11	86.46
		30.18	5.9678	24.21	80.22
		30.06	4.8665	25.19	83.81
		29.84	6.2832	23.56	78.94
		29.10	3.4342	25.67	88.20

Percentage of the Total Utilised Calories against the Total Calories Intake.

Sujets Subject	Période Period	Quantité journalière moyenne de calories absorbées Total calories intake Average per day	Nombre moyen de calories utilisées par jour Utilised calories Average per day	Pourcentage utilisé des calories absorbées % of utilised calories against total calories intake
Higuchi	Période préparatoire Preparatory period	2272.885	2168.022	95.34
	Riz glacé Polished rice	2296.399	2239.149	97.50
	Riz mi-glacé Half-pol. rice	2243.119	2093.873	93.34
	Riz glacé à 70 % 70 % pol. rice	2348.133	2212.181	94.21
	Riz non glacé Unpolished rice	1372.156	1207.637	88.01
	Après Latter	2296.399	2211.117	96.28
Momoyeda	*Idem*	2606.628	2523.685	96.82
		2708.688	2649.831	97.82
		2312.145	2179.816	93.84
		2773.373	2645.879	95.40
		1870.506	1667.591	89.15
		2708.688	2654.835	98.01
Sugisaki	*Idem*	2299.411	2221.857	96.62
		2504.117	2427.222	96.93
		2246.131	2111.418	94.00
		2706.916	2595.078	95.86
		1455.217	1275.728	87.66
		2572.263	2482.182	96.50

Average Means of the Digestibility and Percentage of the Total Utilised Calories.

Période Period	Azote total Total nitrogen %	Hydrates de carbone Carbohydrate %	Graisse brute Crude fat %	Cendres brutes Crude ash %	Calories utilisées Utilised calories %
Riz glacé Polished rice	88.663	99.663	91.610	90.360	97.417
Riz glacé à 70 % 70 % polished rice	80.537	99.210	84.970	84.460	95.157
Riz mi-glacé Half-polished rice	78.220	99.197	80.977	82.153	93.727
Riz non glacé Unpolished rice	69.190	97.090	74.493	80.313	88.273

The mean value obtained for each constituent in each period is taken as representing the digestibility of the corresponding constituent in the different grades of rice. If the crude rice is represented by 100 parts, then the yields of the various grades of polished rice are: polished rice 92.74 parts, 70%-polished rice 94.53 parts and half-polished rice 95.81 parts. The absolute digestible quantity of each constituent of the rice and its absolute output in the fæces were calculated from these data; the results are as shown in the following table:

		Riz glacé cuit Boiled polished rice	Riz glacé à 70 % cuit Boiled 70%-polished rice	Riz mi-glacé cuit Boiled half-polished rice	Riz non glacé cuit Boiled unpolished rice
Quantité fournie par 100 gr. de riz non décortiqué (cru) Amount obtained from 100 gms. of unpolished rice (uncooked)		197.12	215.50	212.98	230.87
Azote total Total nitrogen	Pourcentage Percentage	0.3868	0.4697	0.4940	0.5320
	Quantité Amount	0.7625	1.0122	1.0521	1.2282
	Pourcent. d'absorption % of absorption	88.663	80.537	78.220	69.190
	Quantité absorbée Amount of absorption	0.6761	0.8152	0.8229	0.8498
	Quantité trouvée dans les selles Amount in fæces	0.0864	0.1970	0.2292	0.3784
Hydrates de carbone Carbo-hydrate	*Idem*	30.29 59.71 99.663 59.51 0.20	30.37 65.45 99.210 65.03 0.42	27.97 59.57 99.197 59.15 0.42	30.97 71.50 97.090 69.42 2.08
Graisse brute Crude fat	*Idem*	0.25 0.49 91.610 0.45 0.04	0.45 0.97 84.970 0.82 0.15	0.50 1.06 80.977 0.86 0.20	1.12 2.58 74.493 1.92 0.66
Cendres brutes Crude ash	*Idem*	0.12 0.23 90.360 0.20 0.03	0.18 0.39 84.460 0.33 0.06	0.23 0.49 82.153 0.40 0.09	0.48 1.11 80.313 0.89 0.22

Conclusion.

1. The digestibility and utilisation of rice are always better when the grades of polishing are higher.

The ratio of the actual energy derived from the rice to the total energy value of the rice eaten varies directly with the digestibility.

2. Under standard conditions the absolute output in the fæces of each ingredient of the rice is always smaller when the rice is polished to a higher grade.

The ratio of the absolute digestible quantity of the respective constituents to the output of each in the fæces is notably high in the case of unpolished rice, and it is always smaller when the polishing grade is higher.

3. The quantity of unpolished rice eaten to supplement a diet consisting of the same side dishes is far smaller than the quantity of rice of various grades of polishing ingested under the same conditions. It appears that, in the unpolished rice period, not only is the caloric value insufficient for the requirements of the body, but the absolute output of food in the fæces is greater than in any of the other periods when rice of various grades of polishing is eaten; the nitrogen balance under these circumstances is almost always negative. If the quantity of rice taken were the same in every period, the differences in the degrees of digestibility and utilisation would be much greater.

SECOND REPORT.

Introduction.

This work was carried out to supplement the data recorded in our first report. Formerly, each experiment lasted 13 days and the digestibilities of polished rice, 70%-polished rice, half-polished rice and unpolished rice were compared simultaneously. Here, however, instead of comparing all the grades of rice in one experiment, I selected for each experiment two kinds of rice polished in different grades. This time each experiment lasted six days; on the first two days (the preparatory period) and the last two days, the subjects were given the same kind of rice; during the two days between these periods the rice taken was of a different grade of polishing. On the morning of the seventh day of the experiment, the subjects ate the same kind of rice as on the last two days.

Six experiments were carried out, involving the comparison of polished rice with 70%-polished rice, polished rice with half-polished rice, polished rice with unpolished rice, 70%-polished rice with half-polished rice, and half-polished rice with unpolished rice.

The general methods of the experiment were the same as those described in our first report.

The side dishes employed in the previous experiment were altered in such a way as to change the quality and quantity of the nitrogenous constituents. They were prepared and cooked as shown in the next table. During each experiment a definite and uniform quantity of these dishes was taken.

The side dishes and their constituents were as follows:

Meal	Side dishes	Materials	Quantity
Morning	Miso soup	Wakame	20 gms.
		Miso	38 »
		Dried fish powder	3 »
		Water	300 cc.
	Fuki (boiled)		30 gms.
	Takuwan		30 gms.
Noon	Nitsuke (Stew)	Pork	50 gms.
		Potato (s skins)	100 »
		Burdock	30 »
		Tofu (toasted)	50 »
		Shoyu	40 cc.
		Sugar	30 gms.
		Water	300 cc.
	Daikon (grated)	Daikon	30 gms.
		Shoyu	5 cc.
Evening	Soup	Tofu	100 gms.
		Dried fish powder	3 »
		Shoyu	25 cc.
		Water	300 »
	Nuta (fish salad)	Mackerel	40 gms.
		Cabbage	25 »
		Onion	15 »
		Miso	20 »
		Vinegar	20 cc.
		Sugar	15 gms.
	Takuwan		30 gms.

Note: Fuki is *Petasites japonicus.*

In the above side dishes, there were the following constituents:

	Azote total Total Nitrogen	Protéine brute Crude protein	Hydrates de carbone (comme le glucose) Carbo-hydrate as glucose	Graisse brute Crude fat	Cendres brutes Crude ash	Calories
Morning — Matin	1.2491	7.8069	13.91	2.94	9.71	116.381
Noon — Midi . .	3.5907	22.4419	46.96	3.25	9.05	314.773
Evening — Soir .	2.7329	17.0806	20.32	7.67	9.29	244.637
Total . .	7.5727	47.3294	81.19	13.86	29.05	655.827

Experiment I.

THE COMPARISON OF THE DIGESTIBILITY OF 70%-POLISHED RICE AND UNPOLISHED RICE.

In this experiment, five men were used as subjects and the following results were obtained:

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	(%)*	Azote de NH^3 Ammonia N. (g)	(%)*	Azote de l'acide urique Uric acid N. (g)	(%)*	Azote des bases puriques Purin base N. (g)	(%)*	Azote des acides aminés Amino acid N. (g)	(%)*	Azote de la créatinine Creatinin N. (g)	(%)*	Azote de la créatine Creatin N. (g)	(%)*
Hara	Riz glacé Polished rice	Mai-14 May 15	8.8189	7.1003	80.51	0.1888	2.14	0.0242	0.27	0.1722	1.96	0.4914	5.57	0.5628	6.38	0.0107	0 12
		Moy-Aver	9.1865	7.0142	76.35	0.2275	2.48	0.0166	0.18	0.2262	2.46	0.3780	4.12	0.5653	6.15	0.0192	0.20
			9.0027	7.0573	78 43	0.2082	2.31	0.0204	0.23	0.1992	2.21	0.4347	4.85	0.5641	6.27	0.0150	0.16
	Riz glacé à 70% 70% pol rice	16	9.6462	7.3536	76.23	0.2225	2.31	0.0204	0.21	0.2067	2.14	0.5670	5.88	0.5576	5.78	0.0105	0.11
		17	9.0844	7.9206	87.30	0.2325	2.56	0.0242	0.27	0.1839	2.03	0.5954	6.55	0.5576	6.13	0.0105	0.11
		Moy-Aver	9.3653	7 6371	81.77	0.2275	2.44	0.0223	0.24	0.1953	2.09	0.5812	6.23	0.5576	5.96	0.0105	0.11
	Riz décortiqué Polished rice	18	9.1358	6.8106	74.54	0.1634	1.79	0.0217	0.24	0.1556	1.76	0.6710	7.34	0.5903	6.46	0.0116	0.12
		19	9 3906	7.3845	78.64	0.1380	1.47	0.0268	0.29	0.1608	1.71	0.4064	4.33	0.5601	5.96	0 0134	0 14
		Moy-Aver	9.2632	7.0975	76.59	0.1507	1.63	0.0243	0.27	0.1582	1.74	0.5387	5.84	0 5752	6.21	0.0125	0.13
Higuchi	Riz glacé Polished rice	14	9.7479	7.8208	80.23	0.1988	2.04	0.0249	0.25	0.1607	1.65	0.5198	5.33	0.5474	5.61	0.0153	0.15
		15	11.4321	8.4673	74.07	0.2325	2.03	0.0191	0.17	0.2157	1.89	0.4725	4.13	0.5628	4.92	0.0107	0.09
		Moy-Aver	10.5900	8.1441	77.65	0.2157	2.04	0.0220	0.21	0.1882	1.77	0.4962	4.73	0.5551	5.27	0.0130	0.12
	Riz glacé à 70% 70% pol. rice	16	11.2038	8.8674	79.15	0.1513	1.35	0 0191	0.17	0 2126	1.60	0.6166	5.50	0.5524	4.93	0.0103	0.09
		17	10.1606	8.0855	79.76	0.1970	1.94	0.0255	0.25	0.2328	2.29	0.5954	5.86	0.5628	5.54	0.0164	0.16
		Moy-Aver	10.6822	8.4765	79.46	0.1742	1.65	0.0223	0.21	0.2227	1.95	0.6060	5.68	0.5576	5.24	0.0134	0 13
	Riz glacé Polished rice	18	10.8790	7.6536	70.36	0.1704	1.57	0.0230	0.21	0.1674	1.54	0.6166	5.67	0.5762	5.30	0.0141	0.13
		19	9.9560	7.3274	73.70	0.1310	1.33	0.0219	0.23	0.1694	1.75	0.4725	4.75	0.5735	5.76	0.0112	0.11
		Moy-Aver	10.4175	7.4905	72.03	0.1507	1.46	0.0225	0.21	0.1684	1.65	0.5448	5.21	0.5749	5.53	0.0127	0.12
Momoyeda	Riz glacé Polished rice	14	10.6665	8.3907	78.66	0.2050	1.92	0.0306	0.29	0.2067	1.95	0.5670	5.32	0.6022	5.64	0.0123	0.11
		15	10.5134	6.9105	65.82	0.2063	1.01	0.0204	0.19	0.2194	2.09	0.6143	5.84	0.6082	5.78	0.0125	0.12
		Moy-Aver	10.5900	7.6506	72.24	0.2057	1.47	0.0255	0.24	0.2131	2.02	0.5907	5.58	0.6052	5.71	0.0124	0.12
	Riz glacé à 70 % 70% pol. rice	16	10.7686	7.7112	71.61	0.1925	1.79	0.0242	0.22	0.2126	1.98	0.5953	5.53	0.6144	5.70	0.0129	0.12
		17	9.5477	7.2109	75.52	0.1542	1.62	0.0204	0.21	0.2094	2.20	0.6899	7.23	0.6273	6.57	0.0133	0.14
		Moy-Aver	10.1582	7.4610	73.57	0.1734	1.71	0.0223	0.22	0.2110	2.09	0.6426	6.38	0.6209	6.14	0.0131	0.13

* % de l'azote total. — % against total N.

(Continuation.)

Sujets Subjects	Période Period	Date	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	Azote de l'urée Urea N. (%)*	Azote de NH^3 Ammonia N. (g)	Azote de NH^3 Ammonia N. (%)*	Azote de l'acide urique Uric acid N. (g)	Azote de l'acide urique Uric acid N. (%)*	Azote des bases purique Purin base N. (g)	Azote des bases purique Purin base N. (%)*	Azote des acides aminés Amino acid N. (g)	Azote des acides aminés Amino acid N. (%)*	Azote de la créatinine Creatinin N. (g)	Azote de la créatinine Creatinin N. (%)*	Azote de la créatine Creatin N. (g)	Azote de la créatine Creatin N. (%)*
Momoyeda	Riz glacé Polished rice	Mai-May 18	9.4417	7.1626	75.85	0.1866	1.98	0.0255	0.27	0.1608	1.71	0.4914	5.20	0.6273	6.64	0.0202	0.21
		19	10.5644	7.3315	69.14	0.1333	1.26	0.0193	0.18	0.1608	1.53	0.4347	4.11	0.6207	5.87	0.0198	0.19
		Moy-Aver	10.0031	7.2471	72.63	0.1600	1.62	0.0224	0.23	0.1608	1.62	0.4631	4.66	0.6240	6.26	0.0200	0.20
Suggisaki	Riz glacé Polished rice	14	10.7176	8.4809	79.13	0.2550	2.38	0.0217	0.20	0.1730	1.62	0.5165	4.82	0.5762	5.37	0.0141	0.13
		15	9.9560	7.1384	71.70	0.2600	2.61	0.0153	0.15	0.2309	2.33	0.4725	4.74	0.5735	5.76	0.0169	0.17
		Moy-Aver	10.3368	7.8097	75.42	0.2575	2.49	0.0185	0.18	0.2020	1.98	0.4945	4.78	0.5749	5.57	0.0155	0.15
	Riz glacé à 70 % 70%-pol. rice	16	8.9193	6.8374	76.66	0.1725	1.93	0.0204	0.23	0.1882	2.06	0.4335	4.75	0.4538	5.09	0.0094	0.10
		17	12.8651	9.7296	75.62	0.2027	1.58	0.0253	0.20	0.2592	2.01	0.6710	5.29	0.7792	6.05	0.0265	0.20
		Moy-Aver	10.8922	8.2835	76.14	0.1876	1.76	0.0229	0.22	0.2237	2.04	0.5523	5.02	0.6165	5.57	0.0180	0.15
	Riz glacé Polished rice	18	10.4113	7.6281	73.27	0.1588	1.53	0.0206	0.19	0.2488	2.39	0.6426	6.16	0.5790	5.56	0.0172	0.16
		19	10.6669	7.6159	71.39	0.1358	1.27	0.0241	0.23	0.1503	1.36	0.4914	4.61	0.5790	5.42	0.0172	0.16
		Moy-Aver	10.5391	7.6220	72.33	0.1473	1.40	0.0224	0.21	0.1996	1.88	0.5670	5.39	0.5790	5.49	0.0172	0.16
Tanaka	Riz glacé Polished rice	14	10.2582	7.2064	70.25	0.1950	1.90	0.0179	0.17	0.1644	1.62	0.4347	4.24	0.5251	5.12	0.0700	0.68
		15	10.0581	6.8650	68.25	0.2175	2.16	0.0166	0.17	0.1571	1.56	0.5198	5.17	0.5251	5.22	0.0760	0.75
		Moy-Aver	10.1582	7.0357	69.25	0.2063	2.03	0.0173	0.17	0.1608	1.59	0.4773	4.71	0.5251	5.17	0.0730	0.72
	Riz glacé à 70 % 70%-pol. rice	16	10.0581	7.7412	76.96	0.2188	2.18	0.0204	0.20	0.2188	2.18	0.5387	5.36	0.5251	5.22	0.0760	0.75
		17	9.2375	7.7754	84.17	0.1950	2.10	0.0223	0.25	0.1608	1.74	0.4725	5.11	0.5377	5.82	0.0645	0.70
		Moy-Aver	9.6478	7.7583	80.57	0.2069	2.14	0.0214	0.23	0.1898	1.96	0.5056	5.24	0.5314	5.52	0.0703	0.73
	Riz glacé Polished rice	18	9.9050	8.0083	80.85	0.1519	1.53	0.0215	0.22	0.1725	1.79	0.4253	4.29	0.5377	5.43	0.0645	0.65
		19	9.2886	7.2607	78.06	0.1299	1.40	0.0232	0.26	0.1574	1.69	0.4725	5.09	0 5251	5.65	0.0760	0.81
		Moy-Aver	9.5968	7.6345	79.46	0.1409	1.47	0.0224	0.24	0.1645	1.74	0.4489	4.69	0.5314	5.54	0.0703	0.73

* % de l'azote total. — % against total N.

The Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Hara			Higuchi		
		SO_3 (g)	P_2O_5 (g)	NaCl (g)	SO_3 (g)	P_2O_5 (g)	NaCl (g)
Riz glacé Polished rice	Mai-May 14	1.6391	1.2449	22.770	1.8146	1.5918	23.245
	15	1.7611	1.2445	23.760	1.9209	1.8980	24.851
	Moyenne –Aver.	1.7001	1.2447	23.265	1.8678	1.7449	24.048
Riz glacé à 70% 70% pol. rice	16	1.6679	1.5918	21.780	1.7838	1.6938	25.265
	17	1.4649	1.6735	22.384	1.9888	1.5102	22.572
	Moyenne –Aver.	1.5664	1.6327	22.082	1.8863	1.6020	23.919
Riz glacé Polished rice	18	1.5883	1.2041	24.354	1.8270	1.5918	22.265
	19	1.5238	1.4286	24.060	1.1761	1.5510	24.750
	Moyenne –Aver.	1.5561	1.3164	24.207	1.5016	1.5714	25.008

Période Period	Date	Momoyeda			Sugisaki			Tanaka		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3 (g)	P_2O_5(g)	NaCl(g)	SO_3 (g)	P_2O_5(g)	NaCl(g)
Riz glacé Polished rice	Mai-May 14	1.8215	1.6122	24.354	1.8942	1.6938	22.473	1.6926	1.0816	22.178
	15	1.8407	1.4286	20.790	1.8791	1.8367	21.309	1.8098	1.5510	22.770
	Moyenne –Aver.	1.8311	1.5204	22.572	1.8867	1.7653	21.891	1.7512	1.3163	22.474
Riz glacé à 70% 70% pol. rice	16	1.7156	1.6122	20.295	1.4470	1.4890	20.885	1.9292	1.6938	23.800
	17	1.7406	1.6938	22.968	2.2058	2.3122	22.275	1.6994	1.3877	20.889
	Moyenne –Aver.	1.7281	1.6530	21.632	1.8264	1.9006	21.580	1.8143	1.5408	22.345
Riz glacé Polished rice	18	1.7556	1.4286	22.178	1.8455	1.6938	20.885	1.6452	1.3673	24.948
	19	1.7537	1.4694	20.885	1.6631	1.7347	21.879	1.5636	1.5918	24.150
	Moyenne –Aver.	1.7547	1.4490	21.532	1.7543	1.7143	21.382	1.6044	1.4796	24.549

Nitrogen Balance: the Digestibility and Utilisation and Caloric Value.

Sujets Subject	Période Period	Absorption d'azote Moyenne journalière N. intake Average per day		Azote trouvé dans l'urine Moyenne journalière N. in urine Average per day		Azote trouvé dans les selles Moyenne journalière N. in fæces Average per day		Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière Absorption Average per day			Pourcentage d'absorption % of absorption
		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	
Hara . . .	Riz glacé Polished rice	12.4411	77.7569	9.0027	72.36	1.7898	14.39	+ 1.6486	10.6513	66.5706	272.939	85.61
	Riz glacé à 70% 70% pol. rice	14.1289	88.3057	9.3653	66.28	2.3488	16.62	+ 2.4148	11.7806	73.6257	301.865	83.38
	Riz glacé Polished rice	13.2525	82.8282	9.2632	69.90	1.9331	14.58	+ 2.0562	11.3194	70.7463	290.060	85.42
Higuchi . .	*Idem*	13.2525	82.8282	10.5900	79.92	1.9023	14.35	+ 0.7602	11.3502	70.9388	290.849	85.65
		14.1289	88.3057	10.6822	75.60	2.1948	15.53	+ 1.2519	11.9341	74.5872	305.808	84.47
		13.4554	84.0963	10.4175	77.42	1.8821	13 98	+ 1.1558	11.5733	72.0332	296.676	86.02
Momoyeda .	*Idem*	13.0497	81.5607	10.5900	81.15	1.9690	15.08	+ 0.4907	11.0807	69.2554	283.948	84.92
		14.1289	88.3057	10.1582	71.90	3.3024	23.30	+ 0.6683	10.8265	67.6657	277.429	76.70
		13.2525	82.8282	10.0031	75.48	2.0464	15.52	+ 1.2030	11.2061	70.0382	287.157	84.48
Sugisaki . .	*Idem*	12.6440	79.0250	10.3368	81.75	2.1579	17.06	+ 0.1493	10.4861	66.5381	272.806	82.91
		13.8948	86.8425	10.8922	78.39	2.3126	16.64	+ 0.6900	11.5822	72.5887	298.614	83.36
		13.2525	82.8282	10.5391	79.53	1.8038	13.61	+ 0.9096	11.4487	71.5544	293.373	86.39
Tanaka . .	*Idem*	12.4411	77.7569	10.1582	81.66	1.6241	13.05	+ 0.6588	10.8170	67.6063	277.186	86.95
		14.1289	88.3057	9.6478	68.28	2.3774	11.83	+ 2.1037	11 7515	73.4469	301.132	83.17
		13.2525	82.8282	9.5968	72.42	2.0689	15.68	+ 1.5868	11.1836	69.8976	287.580	84.32

The Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Hara . .	Riz glacé Polished rice	457.63	0.9628	0.21	456.67	1872.347	99.79
	Riz glacé à 70% 70% pol. rice	485.09	1.8438	0.38	483.25	1982.325	99.62
	Riz glacé Polished rice	520.37	1.7743	0.34	518.60	2126.260	99.66
Higuchi .	*Idem*	520.37	1.1468	0.22	519.22	2128.802	99.78
		485.09	1.8184	0.37	483.27	1982.407	99.63
		536.06	1.5686	0.29	534.49	2192.409	99.71
Momoyeda	*Idem*	504.64	1.0044	0.19	503.64	2064.924	99.81
		485.09	2.4593	0.50	482.63	1978.783	99.50
		520.37	1.8713	0.35	518.50	2125.850	99.65
Sugisaki .	*Idem*	473.32	1.3191	0.28	472.00	1935.200	99.72
		470.67	1.6987	0.36	468.97	1922.777	99.64
		520.37	1.8883	0.36	518.48	2125.768	99.64
Tanaka .	*Idem*	457.63	1.1214	0.24	456.51	1871.691	99.76
		485.09	1.8106	0.37	483.28	1981.448	99.63
		520.37	1.6314	0.31	518.74	2126.834	99.69

Digestibility and Utilisation of Crude Fat.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse trouvée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Hara . .	Riz glacé Polished rice	16.02	1.9097	11.92	14.11	131.223	88.08
	Riz glacé à 70% 70% pol. rice	18.90	3.8379	20.31	15.06	140.058	79.69
	Riz glacé Polished rice	16.38	2.8657	17.50	13.51	125.643	82.50
Higuchi .	*Idem*	16.38	2.5375	15.49	13.84	128.712	84.51
		18.90	2.8791	15.30	16.02	148.986	84.70
		16.47	2.2304	13.54	14.24	132.432	86.46
Momoyeda	*Idem*	16.29	1.7289	10.61	14.56	135.408	89.39
		18.90	4.5053	23.83	14.39	133.827	76.17
		16.38	2.4915	15.21	13.89	129.177	84.79
Sugisaki .	*Idem*	16.06	2.0346	12.67	14.03	130.479	87.33
		18.72	3.0194	16.61	15.70	146.010	83.39
		16.38	1.9642	11.98	14.41	134.013	88.02
Tanaka .	*Idem*	16.02	1.7332	10.82	14.29	132.897	89.18
		18.90	4.4907	23.75	14.41	134.013	76.25
		16.38	2.1345	13.03	14.25	132.525	86.97

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres trouvées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Hara . . .	Riz glacé	30.49	2.5215	8.27	91.73
	Polished rice				
	Riz glacé à 70% . . .	31.29	3.8054	12.16	87.84
	70% polished rice . .				
	Riz glacé	30.73	2.4029	7.82	92.18
	Polished rice				
Higuchi .	*Idem*	30.73	3.2844	10.68	89.32
		31.29	3.3639	10.75	89.25
		30.79	2.6655	8.66	91.34
Momoyeda	*Idem*	30.67	3.5922	11.71	88.29
		31.29	4.8981	15.65	84.35
		30.73	3.5597	11.58	88.42
Sugisaki .	*Idem*	30.55	3.6202	11.85	88.15
		31.21	3.8793	12.43	87.57
		30.73	3.1250	10.17	89.83
Tanaka .	*Idem*	30.49	2.5717	8.43	91.57
		31.29	5.0214	16.04	83.96
		30.73	3.0204	9.82	90.18

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Calories utilisation		% de la quantité de calories absorbée % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Hara . .	Riz glacé . . . Polished rice . .	2344.072	42.45	2276.509	41.22	97.11
	Riz glacé à 70% 70% pol. rice . .	2526.692	45.79	2424.248	43.93	95.95
	Riz glacé . . . Polished rice . .	2625.446	47.43	2542.503	45.93	96.84
Higuchi .	*Idem*	2625.446	50.44	2548.363	48.96	97.64
		2526.692	48.28	2437.201	46.55	96.46
		2695.811	51.47	2621.517	50.04	97.21
Momoyeda	*Idem*	2555.124	44.56	2484.280	43.33	98.01
		2526.692	43.96	2390.039	41.58	94.59
		2625.446	45.74	2542.184	44.29	96.83
Sugisaki .	*Idem*	2414.437	44.96	2338.485	43.73	96.44
		2459.897	46.02	2367.401	44.29	96.24
		2625.446	48.98	2553.154	47.63	97.24
Tanaka .	*Idem*	2349.072	44.70	2281.774	43.42	97.13
		2526.692	47.87	2416.593	45.78	95.64
		2625.446	49.88	2546.939	48.39	97.01

I. *Comparison of Polished Rice with 70%-polished Rice.*

The percentages of digestibility and utilised calories were as follows:

Period	Total Nitrogen	Carbo-hydrate	Crude fat	Crude ash	Calories
Preparatory	85.214	99.772	87.698	89.812	97.266
70% polished rice . . .	82.216	99.604	80.040	86.594	95.776
Polished rice	85.326	99.670	85.748	90.392	97.026

The mean of each constituent in each period is taken as representing the digestibility of the particular grade of rice.

The absolute digestibility of each constituent of the rice and the absolute output of each in the fæces have been calculated. The results are as shown in the following table:

		Riz glacé cuit Boiled polished rice	Riz glacé à 70 %, cuit Boiled 70 % polished rice
Quantité fournie par 100 gr. de riz non glacé . . Amount obtained from 100 gms. of unpolished rice		228.16	235.04
Azote total Total nitrogen	Pourcentage — Percentage . . .	0.4057	0.4683
	Quantité — Amount	0.9256	1.1007
	Pourcentage de digestibilitée . . . % of digestibility	85.326	82.216
	Quantité totale utilisée. . . . . . Total amount utilised	0.7898	0.9049
	Total trouvé dans les selles . . . . Total in the fæces	0.1358	0.1958
Hydrocarbures Carbohydrate	*Idem*	31.37 71.57 99.670 71.33 0.24	28.85 67.81 99.604 67.54 0.27
Graisses brutes Crude fat	*Idem*	0.18 0.41 85.748 0.35 0.06	0.36 0.85 80.040 0.68 0.17
Cendres brutes Crude ash	*Idem*	0.12 0.27 90.392 0.24 0.03	0.16 0.38 86.594 3.33 0.04

Experiment II.

THE COMPARISON OF THE DIGESTIBILITY OF HALF-POLISHED RICE AND POLISHED RICE.

In this experiment, five men were used as subjects and the following results were obtained:

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	(%)	Azote de NH_3 Ammonia N. (g)	(%)	Azote de l'acide urique Uric acid N. (g)	(%)	Azote des bases puriques Purin base N. (g)	(%)	Azote des acides aminés Amino acid N. (g)	(%)	Azote de la créatinine Creatinin N. (g)	(%)	Azote de la créatine Creatin N. (g)	(%)
Hara	Riz glacé Polished rice	28 & 29	8.6360	6.8457	79.32	0.1401	1.62	0.0149	0.17	0.2144	2.48	0.5859	6.78	0.6176	7.15	0.0092	0.10
		Mai – May	8.9703	6.8885	76.79	0.1229	1.36	0.0087	0.10	0.1572	1.76	0.6237	6.74	0·5903	6.58	0.0116	0.13
		Moy-Aver	8.8032	6.8671	78.06	0.1315	1.49	0.0118	0.14	0.1858	2.12	0.6048	6.76	0.6040	6.87	0.0104	0.12
	Riz mi-glacé Half-pol. rice	30	9.5832	7.4791	78.04	0.1707	1.79	0.0156	0.16	0.2185	2.28	0.7088	7.40	0.5961	6.22	0.0121	0.12
		31	9.4200	6.8769	73.00	0.0984	1.04	0.0073	0.08	0.2681	2.84	0.6804	7.22	0.5628	6.97	0.0107	0.11
		Moy-Aver	9.5016	7.2780	75.52	0.1346	1.42	0.0115	0.12	0.2433	2.56	0.6940	7.31	0.5795	6.10	0.0114	0.12
	Riz glacé Polished rice	1 & 2	9.6389	7.0027	72.65	0.1744	1.81	0.0101	0.10	0.1538	1.60	0.6710	6 96	0.6022	6.25	0.0123	0.13
		Juin-June	9.5832	6.9404	72.42	0.1425	1.49	0.0184	0.19	0.2381	2.48	0.6332	6.61	0.6082	6.35	0.0125	0.13
		Moy-Aver	9.6111	6.9716	72.54	0.1585	1.65	0.0143	0.15	0.1960	2.01	0.6521	6.79	0.6052	6.30	0.0124	0.13
Higuchi	Riz glacé Polished rice	28 & 29	8.4131	6.7478	80.21	0.0776	0.92	0.0126	0.15	0.2026	2.41	0.7088	8.43	0.5961	7.08	0.0183	0.21
		Mai – May	8.8031	7.1177	80.85	0.0911	1.35	0.0121	0.14	0.1535	1.74	0.6614	7.51	0.5549	6.30	0.0112	0.13
		Moy-Aver	8 6081	6.9328	80.53	0.0844	1.14	0.0124	0.15	0.1781	2.08	0.6851	7.97	0.5755	6.69	0.0148	0.17
	Riz mi-glacé Half-pol. rice	30	10.1403	8.1490	80.36	0.1584	1.56	0.0114	0.11	0.2209	2.18	0.7088	6.99	0.5790	5.71	0.0114	0.11
		31	10.2546	8.7086	84.93	0.1226	1.20	0.0159	0.13	0.2463	2.40	0.8222	8.02	0 5680	5.53	0.0109	0.11
		Moy-Aver	10.1975	8.4288	82.65	0.1450	1.38	0.0137	0.12	0.2336	2.29	0.7655	7.51	0.5735	5.62	0.0112	0.11
	Riz glacé Polished rice	1 & 2	9.4717	7.7799	82.14	0.1180	1.25	0.0170	0.28	0.2014	2.13	0.6804	7.18	0.5680	5.99	0.0109	0.11
		Juin-June	10.3603	7.3205	70.66	0.1278	1.23	0.0073	0.07	0.2068	1.99	0.6143	5.90	0.5735	5.53	0.0169	0.16
		Moy-Aver	9.9160	7.5502	76.40	0.1229	1.24	0.0122	0.18	0.2041	2.06	0.6474	6.54	0.5708	5.76	0.0139	0.14
Momoyeda	Riz glacé Polished rice	28 & 29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		Mai – May	10.6003	7.4106	69.91	0.1107	1.04	0.0114	0.11	0.1529	1.44	0.6521	6.15	0.6406	6.04	0.0136	0.13
		Moy-Aver	10.6003	7.4106	69.91	0.1107	1.04	0.0114	0.11	0.1529	1.44	0.6521	6.15	0.6406	6.04	0.0136	0.13

(Continuation.)

Sujets Subjects	Période Period	Date	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	Azote de l'urée Urea N. (%)	Azote de NH^3 Ammonia N. (g)	Azote de NH^3 Ammonia N. (%)	Azote de l'acide urique Uric acid N. (g)	Azote de l'acide urique Uric acid N. (%)	Azote des bases puriques Purin base N. (g)	Azote des bases puriques Purin base N. (%)	Azote des acides aminés Amino acid N. (g)	Azote des acides aminés Amino acid N. (%)	Azote de la créatinine Creatinin N. (g)	Azote de la créatinine Creatinin N. (%)	Azote de la créatine Creatin N. (g)	Azote de la créatine Creatin N. (%)
Momoyeda	Riz mi-glacé	30 & 31	10.1489	7.6559	75.44	0.1744	1.72	0.0142	0.13	0.2209	2.17	0.9356	9.23	0.6273	6.16	0.0133	0.13
	Half-pol. rice	Mai-May	9.9684	7.0072	70.30	0.1499	1.51	0.0107	0.11	0.2383	2.44	0.5426	5.45	0.6338	6.37	0.0137	0.13
		Moy-Aver	10.0587	7.3316	72.87	0.1622	1.62	0.0125	0.12	0.2296	2.31	0.7391	7.34	0.6306	6.27	0.0135	0.13
	Riz glacé	1 & 2	9.1971	7.2386	78.71	0.1425	1.55	0.0087	0.09	0.1959	2.13	0.7277	7.92	0.6144	6.64	0.0129	0.14
	Polished rice	Juin-June	10.5860	7.0407	66.51	0.1352	1.28	0.0226	0.22	0.2540	2.40	0.6332	5.96	0.6842	6.46	0.0242	0.23
		Moy-Aver	9.8916	7.1397	72.61	0.1389	1.42	0.0157	0.16	0.2250	2.27	0.6805	6.94	0.6493	6.55	0.0186	0.19
Sugisaka	Riz glacé	28 & 29	11.7561	7.3572	62.58	0.1695	1.44	0.0184	0.16	0.2417	2.06	0.6699	5.70	0.6082	5.17	0.0125	0.11
	Polished rice	Mai-May	11.3103	8.1148	71.76	0.1327	1.17	0.0101	0.09	0.2280	2.01	0.5765	5.10	0.6022	5.32	0.0123	0.11
		Moy-Aver	11.5332	7.7360	67.17	0.1511	1.31	0.0143	0.13	0.2349	2.04	0.6232	5.40	0.6052	5.25	0.0124	0.11
	Riz mi-glacé	30	10.6975	8.5501	79.91	0.1817	1.70	0.0156	0.15	0.2584	2.42	0.7088	6.63	0.6022	5.63	0.0184	0.17
	Half-pol. rice	31	12.4247	9.8140	79.00	0.1425	1.15	0.0099	0.09	0.2794	2.20	0.7371	5.77	0.6022	4.84	0.0184	0.14
		Moy-Aver	11.5611	9.1821	79.46	0.1621	1.43	0.0128	0.12	0.2689	2.31	0.7230	6.20	0.6022	5.24	0.0184	0.16
	Riz glacé	1 & 2	11.2546	8.8938	79.02	0.1695	1.51	0.0184	0.16	0.2898	2.57	0.6710	5.96	0.6022	5.35	0.0184	0.16
	Polished rice	Juin-June	11.0849	7.9600	71.81	0.1338	1.21	0.0128	0.12	0.2462	2.22	0.7088	6.39	0.6082	5.48	0.0125	0.11
		Moy-Aver	11 1698	8.4269	75.42	0.1517	1.36	00.156	0.14	0.2680	2.40	0.6899	6.18	0.6052	5.42	0.0155	0.14
Tanaka	Riz glacé	28 & 29	8.2460	6.4796	78.81	0.1327	1.67	0.0240	0.29	0.1609	1.95	0.5670	6.63	0.5762	6.98	0.0259	0.31
	Polished rice	Mai-May	10.2517	7.7021	75.13	0.1768	1.73	0.0156	0.15	0.2118	2.07	0.5670	5.53	0.5846	5.70	0.0298	0.29
		Moy-Aver	9.2489	7.0909	76.97	0.1548	1.70	0.0198	0.22	0.1864	2.01	0.5670	6.08	0.5804	6.34	0.0279	0.30
	Riz mi-glacé	30	10.4189	7.9016	75.80	0.1940	1.86	0.0142	0.13	0.2612	2.51	0.6521	6.26	0.5903	5.66	0.0370	0.35
	Half-pol. rice	31	9.5860	7.8978	82.38	0.1254	1.31	0.0114	0.12	0.2716	2.83	0.6143	6.41	0.5576	5.40	0.0507	0.53
		Moy-Aver	10.0025	7.8997	79.09	0.1597	1.59	0.0128	0.13	0.2664	2.67	0.6332	6.34	0.5740	5.53	0.0439	0.44
	Riz glacé	1 & 2	9.6946	7.7459	79.99	0.1278	1.32	0.0184	0.19	0.2418	2.50	0.6332	6.53	0.5680	5.86	0.0658	0.68
	Polished rice	Juin-June	9.3046	6.9315	74.39	0.1033	1.11	0.0156	0.17	0.2314	2.49	0.5670	6.09	0.5628	6.04	0.0711	0.76
		Moy-Aver	9.4996	7.3432	77.19	0.1156	1.22	0.0170	0.18	0.2368	2.50	0.6001	6.31	0.5654	5.95	0.0685	0.72

The Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Hara			Higuchi		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_3(g)	NaCl(g)
	Mai-May						
	28	1.8544	1.2245	15.438	1.7460	1.1837	18.810
Riz glacé Polished rice	29	1.5808	1.6377	16.830	1.4957	1.5102	17.620
	Moyenne –Aver.	1.7176	1.4311	16.134	1.6209	1.3470	18.215
	30	1.6439	1.7959	26.610	1.7234	1.8776	22.770
Riz mi-glacé Half-pol. rice	31	1.6157	1.5918	22.770	1.6638	1.7551	25.265
	Moyenne –Aver.	1.6298	1.6939	24.690	1.6936	1.8164	24.018
	Juin-June						
Riz glacé	1	1.6610	1.4286	26.037	1.6528	1.5918	24.459
Polished rice	2	1.7762	1.3673	24.750	1.8105	1.6122	23.760
	Moyenne –Aver.	1.7186	1.3980	25.394	1.7317	1.6020	24.110

Periode Period	Date	Momoyeda			Sugisaki			Tanaka		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
	Mai-May									
Riz glacé	28	—	—	—	2.1328	1.3877	17.600	1.6860	0.8775	18.117
Polished rice	29	1.7328	1.5306	16.830	1.8736	1.9288	19.305	1.7659	1.7959	19.602
	Moyenne –Aver.	1.7328	1.5306	16.830	2.0032	1.6633	18.463	1.7260	1.3367	18.860
	30	1.6754	1.8571	24.057	1.9538	1.7551	22.572	1.7652	1.9388	22.770
Riz mi-glacé	31	1.6473	1.3877	23.661	1.9854	1.9796	26.431	1.7344	1.8367	24.355
Half-pol. rice	Moyenne –Aver.	1.6614	1.6224	23.859	1.9696	1.8674	24.502	1.7498	1.8878	23.563
	Juin-June									
Riz glacé	1	1.5342	1.2245	23.245	1.9477	2.2714	25.867	1.7550	1.6938	25.146
Polished rice	2	1.8846	1.0205	24.552	1.9861	1.7551	25.344	1.7412	1.4490	22.958
	Moyenne –Aver.	1.7094	1.1225	23.899	1.9669	2.0135	25.606	1.7486	1.5714	24.052

Sujets Subject	Période Period	Absorption d'azote Moyenne journalière N. intake Average per day		Azote trouvé dans l'urine Moyenne journalière N. in urine Average per day		Azote trouvé dans les selles Moyenne journalière N. in fæces Average per day		Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière Absorption Average per day			Pourcentage d'absorption % of absorption
		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	
Hara . . .	Riz glacé Polished rice	13.2525	82.8282	8.8032	67.18	1.9213	14 49	+ 2.5280	11.3312	73.3390	290.362	85.51
	Riz mi-glacé Half-pol. rice	14.0025	87.5157	9.5016	67.85	2.2681	16.19	+ 2.2328	11.7344	73.3390	300.690	83.81
	Riz glacé Polished rice	13.2525	82.8282	9.6111	72 53	1.5942	12.03	+ 2.0472	11.6583	72.8644	298.740	87.97
Higuchi . .	*Idem*	13.0497	81.5607	8.6081	65.81	2.4735	18.95	+ 1.9681	10.5762	66.1013	271.015	81.05
		14.0025	87.5157	10.1975	72.82	2.7893	19.92	+ 1.0157	11.2132	69.1824	283.688	80.08
		13.2525	82.8282	9.9160	74.82	1.9611	14.79	+ 1.3754	11.2914	70.5614	289.302	85.21
Momoyeda	*Idem*	13.2525	82.8282	10.6003	79.98	1.8177	13.71	+ 0.8345	11.4348	71.4665	293.013	86.29
		14.4971	90.6069	10.0587	69.38	2.5531	17.61	+ 1.8853	11.9440	74.6400	306.024	82.39
		13.2525	82.8282	9.8916	74.64	1.3917	10.50	+ 1.9692	11.8608	74.1300	303.933	89.50
Sugisaki . .	*Idem*	13.2525	82.8282	11.5332	87.02	1.8141	13.68	— 0.0948	11.4384	71.4900	293.109	86.32
		13.7552	85.9700	11.5611	83.32	2.3679	17.21	— 0.1738	11.9411	74.6319	305.991	82.79
		13.2525	82.8282	11.1698	84.28	1.5865	11.97	+ 0.4862	11.6660	72.9125	298.941	88.03
Tanaka . .	*Idem*	12.4411	77.7569	9.2489	74.34	1.3034	10.48	+ 1.8888	11.1377	69.6106	285.403	89.52
		13.5079	84.4244	10.0025	74.05	2.5306	18.73	+ 0.9748	10.9773	68.6081	281.293	81.27
		12.4411	77.7569	9.4996	76.36	1.8605	14.95	+ 1.0810	10.5806	66.1288	271.128	85.05

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Hara . .	Riz glacé Polished rice	520.37	1.6843	0.32	518.69	2126.629	99.68
	Riz mi-glacé Half-pol. rice.	416.46	2.5833	0.62	413.88	1696.908	99.38
	Riz glacé Polished rice	520.37	1.5055	0.29	518.86	2127.326	99.71
Higuchi .	*Idem*	504.64	2.0635	0.41	502.58	2060.578	99.59
		416.46	3.6910	0.87	412.77	1692.357	99.13
		520.37	1.5577	0.29	518.81	2127.121	99.71
Momoyeda	*Idem*	520.37	1.3557	0.26	519.01	2127.941	99.74
		442.25	2.5117	0.57	439.74	1802.934	99.43
		520.37	1.2724	0.24	519.10	2128.310	99.76
Sugisaki .	*Idem*	520.37	1.4882	0.28	518.88	2127.408	99.72
		403.57	2.3491	0.58	401.22	1645.002	99.42
		520.37	1.6347	0.31	518.74	2126.834	99.69
Tanaka .	*Idem*	457.63	0.9026	0.19	456.73	1872.593	99.81
		490.67	2.4487	0.62	388.22	1591.702	99.38
		457.63	1.6515	0.36	455.98	1869.518	99.64

Digestibility and Utilisation of Crude Fat.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Hara . .	Riz glacé Polished rice	16.38	1.6383	10.00	14.74	137.082	90.00
	Riz mi-glacé Half-pol. rice	20.62	4.8030	23.29	15.82	147.126	76.71
	Riz glacé Polished rice	16.38	1.7120	10.45	14.67	136.431	89.55
Higuchi .	*Idem*	16.29	2.4817	15.23	13.81	128.433	84.77
		20.62	4.3458	21.07	16.27	151.311	78.93
		16.38	1.6844	10.28	14.70	136.710	89.72
Momoyeda	*Idem*	16.38	1.7863	10.90	14.59	135.687	89.10
		21.14	4.7179	22.31	16.42	152.706	77.69
		16.38	2.0327	12.41	14.35	133.455	87.59
Sugisaki .	*Idem*	16.38	1.3459	8.21	15.03	139.779	91.79
		20.36	4.3758	21.49	15.98	148.614	78.51
		16.38	1.8758	11.45	14.50	134.850	88.55
Tanaka .	*Idem*	16.02	1.2672	7.91	14.76	137.268	92.00
		20.10	4.5799	22.78	15.52	144.336	77.22
		16.02	1.7438	10.88	14.28	132.804	89.12

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Pourcentage d'absorption % of absorption
Hara . . .	Riz glacé	30.73	2.2471	7.32	92.68
	Polished rice				
	Riz mi-glacé	31.13	4.0905	13.14	86.86
	Half-polished rice . .				
	Riz glacé	30.73	2.2751	7.40	92.60
	Polished rice				
Higuchi .	*Idem*	30.67	2.9533	9.62	90.38
		31.13	4.3637	14.01	85.99
		30.73	2.8881	9.40	90.60
Momoyeda	*Idem*	30.73	2.3464	7.63	92.37
		31.29	3.5647	11.39	88.61
		30.73	2.4659	8.02	91.98
Sugisaki .	*Idem*	30.73	2.8230	9.12	90.88
		31.05	4.7050	11.15	84.85
		30.73	2.9829	9.70	90.30
Tanaka . .	*Idem*	30.49	1.9803	6.49	93.51
		30.97	5.2533	16.96	83.04
		30.49	3.0542	10.02	89.98

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Caloric utilisation		% de la quantité de calories absorbée % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Hara . .	Riz glacé	2625.446	47.62	2554.073	46.33	97.24
	Polished rice . .					
	Riz mi-glacé . .	2258.066	40.94	2144.724	38.89	94.98
	Half-pol. rice . .					
	Riz glacé. . . .	2625.446	47.56	2562.497	46.33	97.60
	Polished rice . .					
Higuchi .	*Idem*	2555.124	48.57	2460.026	46.77	96.28
		2258.066	42.69	2127.356	40.21	94.21
		2625.446	49.91	2553.133	48.54	97.25
Momoyeda	*Idem*	2625.446	45.27	2556.641	44.08	97.38
		2381.315	41.02	2261.664	38.96	94.98
		2625.446	45.20	2565.698	42.45	97.72
Sugisaki .	*Idem*	2625.446	48.53	2560.296	47.33	97.52
		2196.461	40.71	2099.607	38.92	95.59
		2625.446	49.07	2560.625	47.86	97.53
Tanaka .	*Idem*	2349.072	44.71	2295.264	43.53	97.71
		2134.816	40.49	2017.331	38.26	94.50
		2349.072	44.57	2273.450	43.14	96.78

II. *Comparison of Polished Rice with 50%-polished Rice.*

The percentages of digestibility and utilised calories were as follows:

	Total Nitrogen	Carbo-hydrate	Crude fat	Crude ash	Calories
Preparatory period . .	85.738	99.708	89.550	91.954	97.226
Half-polished rice period	82.064	99.348	77.812	85.870	94.852
Polished rice period . .	87.132	99.702	88.906	91.092	97.376

The absolute digestibility of each constituent of the rice and the absolute output of each in the fæces have been calculated as in the previous experiment. The results are as shown in the following table:

		Riz glacé cuit Boiled polished rice	Riz mi-glacé cuit Boiled half-polished rice
Quantité fournie par 100 gr. de riz non glacé Amount obtained from 100 gms. of unpolished rice.		228.16	272.16
Azote total Total nitrogen	Pourcentage — Percentage . . .	0.4057	0.4946
	Quantité — Amount	0.9256	1.3641
	Pourcentage de digestibilité . . . . % of digestibility	87.132	82.061
	Quantité totale utilisé . . . . . . Total amount utilised	0.8065	1.1046
	Total trouvé dans les selles . . . . Total in the fæces	0.1191	0.2415
Hydrates de carbone Carbo-hydrate	*Idem*	31.37 71.57 99.702 71.36 0.21	25.79 60.19 99.348 59.80 0.39
Graisse brute Crude fat	*Idem*	0.18 0.41 88.906 0.36 0.05	0.52 1.41 77.812 1.10 0.31
Cendres brutes Crude ash	*Idem*	0.12 0.27 91.092 0.25 0.02	0.16 0.44 85.870 0.38 0.06

Experiment III.

THE COMPARISON OF THE DIGESTIBILITY OF UNPOLISHED RICE AND POLISHED RICE.

In this experiment, four men were used as subjects and the following results were obtained:

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date	Azote total Total N. (g)	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
				(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Higuchi		**Juin-June**															
	Riz glacé Polished rice	14	10.3075	8.2603	80.14	0.1678	1.66	0.0142	0.14	0.2659	2.58	0.5670	5.50	0.5680	5.51	0.0109	0.10
		15	10.3636	7.9825	77.02	0.1156	1.12	0.0170	0.16	0.2417	2.34	0.8505	8.21	0.5903	5.70	0.0116	0.11
		Moy-Aver	10.3356	8.1214	78.58	0.1417	1.39	0.0156	0.15	0.2538	2.46	0.7088	6.86	0.5792	5.61	0.0113	0.11
	Riz non glacé Unpol. rice	16	10.3075	8.5533	82.98	0.1866	1.82	0.0114	0.11	0.2569	2.49	0.6521	6.33	0.5762	5.59	0.0141	0.13
		17	10.6975	8.6301	80.67	0.1744	1.63	0.0142	0.13	0.2531	2.37	0.8033	7.51	0.5846	5.46	0.0175	0.16
		Moy-Aver	10.5025	8.5917	81.83	0.1805	1.73	0.0128	0.12	0.2550	2.43	0.7277	6.92	0.5804	5.53	0.0158	0.15
	Riz glacé Polished rice	18	10.3075	8.2754	80.28	0.1156	1.12	0.0147	0.14	0.2657	2.57	0.8355	8.11	0.5735	5.56	0.0169	0.16
		19	9.4160	7.4340	78.95	0.1401	1.49	0.0119	0.12	0.1931	2.05	0.7889	9.33	0.6051	6.42	0.0093	0.10
		Moy-Aver	9.8618	7.8547	79.62	0.1279	1.31	0.0133	0.13	0.2294	2.31	0.8572	8.72	0.5893	5.99	0.0131	0.13
Momoyeda	Riz glacé Polished rice	14	8.6360	6.6567	77.08	0.1524	1.61	0.0240	0.28	0.2133	2.47	0.7749	8.97	0.6338	7.34	0.0137	0.16
		15	9.9732	7.4430	74.63	0.1776	1.78	0.0198	0.20	0.2501	2.51	0.7839	7.86	0.6406	6.42	0.0136	0.14
		Moy-Aver	9.3046	8.0499	75.86	0.1650	1.70	0.0219	0.24	0.2317	2.24	0.7794	8.42	0.6372	6.88	0.0137	0.15
	Riz non glacé Unpol. rice	16	9.7503	8.0722	82.69	0.1425	1.46	0.0140	0.14	0.1913	1.96	0.6521	6.68	0.6273	6.43	0.0133	0.13
		17	10.0846	7.5009	74.38	0.1229	1.22	0.0212	0.21	0.1537	1.53	0.8789	8.72	0.6338	6.28	0.0204	0.20
		Moy-Aver	9.9175	7.7866	78.54	0.1327	1.34	0.0176	0.18	0.1725	1.75	0.7655	7.70	0.6306	6.36	0.0169	0.17
	Riz glacé Polished rice	18	10.5860	7.2865	68.83	0.2038	1.93	0.0184	0.17	0.2433	2.30	0.4819	4.55	0.6475	6.11	0.0142	0.13
		19	10.8089	7.2904	67.45	0.1903	1.76	0.0142	0.13	0.2481	2.30	0.8883	8.24	0.6475	5.99	0.0216	0.20
		Moy-Aver	10.6975	7.2885	68.14	0.1971	1.90	0.0163	0.15	0.2457	2.30	0.6851	6.40	0.6475	6.05	0.0179	0.17

(Continued.)

Subjects Sujets	Période Period	Date	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
			(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Sugisaki	Riz glacé Polished rice	Juin-June 14	9.3075	7.3666	79.15	0.0617	0.66	0.0156	0.17	0.2243	2.41	0.7938	8.53	0.6022	6.47	0.0123	0.13
		15	9.6418	7.2866	75.57	0.1511	1.57	0.0101	0.10	0.1733	1.79	0.9072	9.41	0.6144	6.37	0.0129	0.13
		Moy-Aver	9.4747	7.3266	77.36	0.1064	1.12	0.0129	0.14	0.1988	2.10	0.8505	8.97	0.6083	6.42	0.0126	0.13
	Riz non glacé Unpol. rice	16	9.1014	7.2758	79.94	0.1588	1.74	0.0114	0.13	0.1776	1.45	0.7088	7.78	0.6022	6.61	0.0123	0.13
		17	10.0289	8.3458	83.32	0.1597	1.59	0.0142	0.14	0.2327	2.32	0.6899	6.88	0.6082	6.06	0.0190	0.19
		Moy-Aver	9.5652	7.8108	81.63	0.1593	1.62	0.0128	0.14	0.2052	2.14	0.6994	7.33	0.6052	6.34	0.0157	0.16
	Riz glacé Polished rice	18	9.7403	7.9661	81.78	0.1329	1.36	0.0142	0.15	0.2561	2.68	0.6332	6.50	0.6176	6.34	0.0160	0.16
		19	8.9743	6.9078	76.85	0.1535	1.71	0.0095	0.10	0.2382	2.66	0.8411	9.37	0.5903	6.58	0.0116	0.13
		Moy-Aver	9.3673	7.4370	79.32	0.1432	1.54	0.0119	0.13	0.2472	2.67	0.7372	7.94	0.6040	6.46	0.0138	0.15
Tanaka	Riz glacé Polished rice	14	10.5303	7.6927	73.05	0.1131	1.07	0.0170	0.16	0.2556	2.43	0.5426	5.15	0.5735	5.44	0.0741	0.70
		15	10.1960	8.0129	78.59	0.1229	1.21	0.0170	0.17	0.2012	1.97	0.5670	5.56	0.4576	4.48	0.0899	0.88
		Moy-Aver	10.3632	7.8528	75.82	0.1180	1.14	0.0170	0.17	0.2284	2.20	0.5548	5.36	0.5156	4.96	0.0820	0.79
	Riz non glacé Unpol. rice	16	10.8646	9.0338	83.15	0.1793	1.65	0.0142	0.13	0.1568	1.91	0.5481	5.04	0.5790	5.33	0.1052	0.97
		17	10.8646	8.6468	79.49	0.1229	1.13	0.0198	0.18	0.2389	2.20	0.7088	6.52	0.5903	5 43	0.0862	0.79
		Moy-Aver	10.8646	8.8403	81.32	0.1511	1.39	0.0170	0.16	0.1979	2.06	0.6285	5.78	0.5847	5.38	0.0957	0.88
	Riz glacé Polished rice	18	10.8646	8.3161	76.54	0.1927	1.77	0.0101	0.09	0.2457	2.26	0.5670	5.22	0.5903	5.33	0.0639	0.58
		19	10.0846	8.0491	79.82	0.1087	1.07	0.0128	0.13	0.1646	1.63	0.6048	6.00	0.5580	5.53	0.1011	1.00
		Moy-Aver	10.4746	8.1826	78.18	0.1507	1.42	0.0115	0.11	0.2052	1.95	0.5859	5.61	0.5742	5.43	0.0821	0.79

The Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Higuchi			Momoyeda		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
	Juin-June						
	14	1.7872	1.6531	25.265	1.4594	1.3265	22.770
Riz glacé	15	1.7900	1.3673	25.661	1.6775	1.3469	25.661
Polished rice	Moyenne — Aver.	1.7886	1.5102	25.463	1.5685	1.3367	24.216
	16	1.7200	1.7959	21.186	1.6651	1.5306	22.572
Riz non glacé	17	1.7858	1.6531	24.948	1.8268	1.4081	27.522
Unpol. rice	Moyenne — Aver.	1.7529	1.7245	23.067	1.7460	1.4694	25.047
	18	1.6864	1.4490	20.889	2.0718	1.7959	21.580
Riz glacé	19	1.7460	1.3877	26.235	1.8482	1.6122	23.760
Polished rice	Moyenne — Aver.	1.7162	1.4184	23.562	1.9600	1.7041	22.670

Période Period	Date	Sugisaki			Tanaka		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
	Juin-June						
	14	1.7623	1.4081	24.750	1.9724	1.3877	26.431
Riz glacé	15	1.8414	1.6735	25.265	1.8640	1.6377	20.291
Polished rice	Moyenne — Aver.	1.8019	1.5408	25.008	1.9182	1.5127	23.361
	16	1.7174	1.6377	22.077	1.9916	1.8571	24.552
Riz non glacé	17	1.9257	1.6122	24.750	2.0485	1.7341	24.869
Unpol. rice	Moyenne — Aver.	1.8366	1.6250	23.414	2.0201	1.7959	24.711
	18	1.7570	1.5306	23.463	1.9223	1.6377	20.790
Riz glacé	19	1.7035	1.5510	24.354	1.8681	1.6122	21.780
Polished rice	Moyenne — Aver.	1.7303	1.5408	23.909	1.8952	1.6250	21.290

Nitrogen Balance: the Digestibility and Utilisation, and Caloric Value.

Sujets / Subject	Période / Period	Absorption d'azote Moyenne journalière — N. intake Average per day		Azote trouvé dans l'urine Moyenne journalière — N. in urine Average per day		Azote trouvé dans les selles Moyenne journalière — N. in fæces Average per day		Gains ou pertes en azote / Nitrogen balance	Absorption Moyenne journalière — Absorption Average per day			Pourcentage d'absorption / % of absorption
		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	
Higuchi . .	Riz glacé Polished rice	12.4411	77.7569	10.3356	83.07	2.2798	18.32	— 0.1743	10.1613	63.5081	260.383	81.68
	Riz non glacé Unpolished rice	12.2896	76.8100	10.5025	85.45	2.9415	24.02	— 1.1544	9.3481	58.4256	239 545	75.98
	Riz glacé Polished rice	12.4411	77.7569	9.8618	79.27	1.9756	15.88	+ 0.6037	10.4655	65.4094	268.179	84.12
Momoyeda	*Idem*	12.2383	76.4894	9.3046	76.03	2.0395	16.66	+ 0.8942	10.1988	63.7425	261.344	83.34
		13.0758	81.7238	9.9175	75.84	3.0728	23.50	+ 0.0855	10.0030	62.5188	256.327	76.50
		13.0497	81.5607	10.6975	81.98	2.0232	15.50	+ 0.3290	11.0265	68.9156	282.554	84.50
Sugisaki . .	*Idem*	12.4411	77.7569	9.4747	76.15	2.2535	18.11	+ 0.7129	10.1876	63.6725	261.057	81.89
		12.2896	76.8100	9.5652	77.83	2.3813	19.37	+ 0.3431	9.9083	61.9269	253.900	80.63
		12.6440	79.0250	9.3673	74.08	1.3612	10.76	+ 0.9181	11.2828	70.5175	289.122	89.24
Tanaka . .	*Idem*	12.4411	77.7569	10.3632	83.29	1.6555	13.31	+ 0.4224	10.7856	67.4100	276.381	86.69
		11.7655	73.5344	10.8646	92.35	2.5947	22.05	— 1.6938	9.1708	51.3175	210.402	77.95
		12.0454	75.2213	10.4746	86.96	2.1956	18.23	— 0.6248	9.8498	61.5613	252.401	81.77

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Higuchi .	Riz glacé Polished rice	457.63	1.8286	0.39	455.80	1868.780	99.61
	Riz non glacé Unpolished rice	268.75	4.4427	1.65	264.31	1043.671	98.35
	Riz glacé Polished rice	457.63	1.4371	0.31	456.19	1870.379	99.69
Momoyeda	*Idem*	441.95	1.5982	0.36	440.35	1805.435	99.64
		300.01	3.8228	1.27	296.19	1214.379	98.73
		504.64	1.9615	0.38	502.68	2060.988	99.62
Sugisaki .	*Idem*	457.63	1.8063	0.39	455.82	1868.862	99.61
		268.75	2.4370	0.91	266.31	1091.871	99.09
		473.32	1.3304	0.28	471.99	1935.159	99.72
Tanaka .	*Idem*	457.63	1.4958	0.33	456.13	1870.133	99.67
		247.91	3.0568	1.23	244.85	1003.885	98.77
		426.26	1.4208	0.34	424.84	1741.844	99.66

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Higuchi .	Riz glacé Polished rice	16.02	1.5811	9.87	14.44	134.292	90.13
	Riz non glacé Unpolished rice	21.24	7.6276	35.91	13.61	126.573	64.09
	Riz glacé Polished rice	16.02	2.1050	13.14	13.91	129.363	86.86
Momoyeda	*Idem*	15.93	1.8719	11.75	14.06	130.758	88.25
		22.47	8.9728	39.93	13.51	125.643	60.07
		16.29	3.1855	19.55	13.10	121.830	80.45
Sugisaki .	*Idem*	16.02	2.2036	13.75	13.82	128.526	86.25
		21.24	6.2441	29.40	15.00	139.500	70.60
		16.11	1.8708	11.61	14.24	132.432	88.39
Tanaka .	*Idem*	16.02	1.4912	9.33	14.53	135.129	90.67
		20.42	8.4215	41.42	12.00	111.600	58.76
		15.84	1.9851	12.53	13.85	128.805	87.47

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Higuchi .	Riz glacé	30.49	2.9090	9.54	90.45
	Polished rice				
	Riz non glacé	32.11	6.9590	21.67	78.33
	Unpolished rice . . .				
	Riz glacé	30.49	2.4626	8.08	91.92
	Polished rice				
Momoyeda	*Idem*	30.43	2.1992	7.23	92.77
		32.62	6.2698	19.22	80.78
		30.67	2.9560	9.64	90.36
Sugisaki .	*Idem*	30.49	2.7745	9.10	90.90
		32.11	5.1327	16.00	84.00
		30.55	2.5644	8.40	91.60
Tanaka .	*Idem*	30.49	2.4897	8.16	91.84
		31.77	7.3193	23.04	76.96
		30.37	2.8091	9.25	90.75

The Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Caloric utilisation		% de la quantité de calories absorbée % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Higuchi .	Riz glacé . . . Polished rice . .	2349.072	44.96	2263.455	43.32	96.35
	Riz non glacé . . Unpolished rice .	1614.327	30.89	1409.789	26.98	87.34
	Riz glacé . . . Polished rice . .	2349.072	44.66	2267.921	43.11	96.53
Momoyeda	*Idem*	2273.564	39.47	2197.537	38.11	96.55
		1774.079	30.77	1596.349	27.70	90.02
		2555.124	44.44	2465.372	42.87	96.47
Sugisaki .	*Idem*	2349.072	44.03	2258.445	42.33	96.14
		1614.327	30.46	1485.271	28.02	91.99
		2414.437	45.55	2356.713	44.47	97.62
Tanaka .	*Idem*	2349.072	44.68	2281.643	43.39	97.11
		1507.828	28.65	1325.887	25.36	88.52
		2202.920	42.18	2123.050	40.65	96.37

III. *Comparison of Polished Rice with Unpolished Rice.*

The percentages of digestibility and utilised calories were as follows:

	Total Nitrogen	Carbo-hydrate	Crude fat	Crude ash	Calories
Preparatory period . .	83.400	99.633	88.825	91.490	96.538
Unpolished rice period .	77.765	98.735	63.380	80.018	89.468
Polished rice period . .	84.908	99.673	85.793	91.158	96.748

The absolute digestible quantity of each constituent of the rice and the absolute output of each in the fæces have been calculated; the results are shown in the following table:

		Riz glacé cuit Boiled polished rice	Riz non glacé cuit Boiled unpolished rice
Quantité fournie par 100 gr. de riz non glacé . . Amount obtained from 100 gms. of unpolished rice.		228.16	263.86
Azote total Total nitrogen	Pourcentage — Percentage . . .	0.4057	0.5241
	Quantité — Amount	0.9256	1.3829
	Pourcentage de digestibilité . . . . % of digestibility	84.908	77.765
	Quantité totale utilisée . . . . . . Total amount utilised	0.7859	1.0754
	Total trouvé dans les selles . . . . Total in the fæces	0.1397	0.3075
Hydrates de carbone		31.37	20.84
		71.57	54.99
	Idem	99.673	98.735
Carbo-hydrate		71.34	54.29
		0.23	0.70
Graisse brute		0.18	0.82
		0.41	2.16
	Idem	85.793	63.380
Crude fat		0.35	1.37
		0.06	0.79
Cendres brutes		0.12	0.34
		0.27	0.90
	Idem	91.158	80.018
Crude ash		0.25	0.72
		0.02	0.18

Experiment IV.

The Comparison of the Digestibility of Half-polished Rice and 70%-polished Rice.

In this experiment, five men were used as subjects and the following results were obtained.

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date	Azote total Total N. (g)	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
				(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Sugimoto	Riz glacé	Sept. 29	10.0232	8.0614	80.43	0.1255	1.25	0.0201	0.20	0.2398	2.39	0.6774	6.16	0.5282	5.29	0.0143	0.14
	à 70 %	30	9.3800	7.2903	77.83	0.1574	1.68	0.0268	0.29	0.1655	1.77	0.5974	6.37	0.5282	5.63	0.0193	0.21
	70% pol. rice	Moy-Aver	9.7016	7.6759	79.13	0.1415	1.47	0.0235	0.25	0.2027	2.08	0.6374	6.27	0.5282	5.46	0.0168	0.18
	Riz mi-glacé	Oct. 1	10.0232	8.0485	80.30	0.1795	1.79	0.0215	0.21	0.2703	2.69	0.6546	6.53	0.5484	5.47	0.0315	0.31
	Half-pol. rice	2	9.7016	7.8667	81.07	0.1451	1.50	0.0268	0.28	0.1377	1.42	0.5746	5.92	0.5484	5.65	0.0260	0.27
		Moy-Aver	9.8624	7.9576	80.69	0.1623	1.65	0.0242	0.25	0.2040	2.06	0.6146	6.23	0.5484	5.56	0.0288	0.29
	Riz glacé	Oct. 3	9.8088	7.6382	77.87	0.1574	1.60	0.0174	0.17	0.1014	1.04	0.6888	7.02	0.5376	5.48	0.0148	0.11
	à 70 %	4	9.7552	7.6238	78.15	0.1525	1.56	0.0188	0.12	0.1027	1.05	0.6203	6.36	0.5524	5.87	0.0103	0.11
	70% pol. rice	Moy-Aver	9.7820	7.6310	78.01	0.1550	1.58	0.0181	0.15	0.1021	1.05	0.6546	6.69	0.5450	5.63	0.0126	0.11
Inoue	Riz glacé	Sept. 29	8.2544	6.7592	81.89	0.2187	2.65	0.0282	0.34	0.1211	1.47	0.8031	9.73	0.5484	6.64	0.0101	0.12
	à 70 %	30	9.5944	7.6372	79.60	0.2678	2.79	0.0228	0.24	0.1423	1.48	0.7217	7.52	0.5376	5.60	0.0148	0.15
	70% pol. rice	Moy-Aver	8.9244	7.1982	80.75	0.2433	2.72	0.0255	0.27	0.1317	1.48	0.7624	8.63	0.5430	6.12	0.0125	0.14
	Riz mi-glacé	Oct. 1	9.4330	7.6078	80.65	0.1353	1.43	0.0228	0.23	0.2070	2.20	0.7802	8.27	0.5103	5.40	0.0179	0.19
	Half-pol. rice	2	8.9512	6.9726	77.90	0.2187	2.44	0.0225	0.25	0.1550	1.73	0.7459	8.33	0.4976	5.56	0.0126	0.14
		Moy-Aver	9.1921	7.2902	79.28	0.1770	1.94	0.0227	0.24	0.1810	1.97	0.7631	8.30	0.5040	5.48	0.0153	0.17
	Riz glacé	Oct. 3	9.4330	7.4739	79.23	0.1663	1.66	0.0215	0.23	0.1240	1.32	0.8716	9.25	0.5103	5.41	0.0133	0.14
	à 70 %	4	8.5760	6.9076	80.55	0.1942	2 27	0.0174	0.20	0.0959	1.12	0.7231	8.43	0.5103	5.94	0.0133	0.16
	70% pol. rice	Moy-Aver	9.0045	7.1908	79.89	0.1803	1.97	0.0195	0.22	0.1100	1.22	0.7974	8.84	0.5103	5.68	0.0133	0.15
Ishibashi	Riz glacé	Sept. 29	7.9824	6.5191	81.67	0.1672	2.10	0.0242	0.30	0.1165	1.46	0.8487	10.63	0.4895	6.13	0.0081	0.10
	à 70 %	30	9.3800	7.4274	79.18	0.2506	2.67	0.0255	0.27	0.1217	1.30	0.9173	9.78	0.4817	5.14	0.0117	0.12
	70% pol. rice	Moy-Aver	8.6812	6.9733	80.43	0.2039	2.39	0.0249	0.29	0.1191	1.88	0.8830	10.21	0.4856	5.64	0.0099	0.11
	Riz mi-glacé	Oct. 1	8.4152	6.6753	79.32	0.2392	2.84	0.0215	0.26	0.1424	1.69	0.9401	11.17	0.4364	5.19	0.0097	0.12
	Half-pol. rice	2	9.3800	7.0504	75.27	0.2408	2.57	0.0268	0.29	0.1882	2.01	1.0772	11.48	0.4364	4.65	0.0130	0.14
		Moy-Aver	8.8976	6.8629	77.30	0.2400	2.71	0.0242	0.28	0.1653	1.85	1.0087	11.33	0.4364	4.92	0.0114	0.13

(Continuation.)

Subjects Sujets	Période Period	Date	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
			(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Ishibashi	Riz glacé	Oct. 3	9.6480	7.2986	75.65	0.1917	1.99	0.0228	0.24	0.1188	1.23	0.9858	10.22	0.4301	4.46	0.0159	0.16
	à 70 %	4	8.7368	7.0818	81.06	0.1966	2.25	0.0201	0.23	0.0982	1.13	0.8716	9.86	0.4562	5.23	0 0143	0.16
	70% pol. rice	Moy-Aver	9.1924	7.1902	78.36	0.1942	2.12	0.0215	0.24	0.1085	1.18	0.9287	10.04	0.4432	4.95	0.0151	0.16
Kayano	Riz glacé	Sept. 29	8.3080	7.3531	88.51	0.1991	2.40	0.0228	0.27	0.1462	1.76	0.4147	4.99	0.4395	5.29	0.0099	0.12
	à 70 %	30	8.4148	6.5249	77.54	0.1795	2.13	0.0242	0.29	0.1550	1.84	0.4489	5.33	0.4562	5.42	0.0071	0.08
	70% pol. rice	Moy-Aver	8.3614	6.9390	83.03	0.1893	2.27	0.0235	0.28	0.1506	1.80	0.4318	5.16	0.4479	5.36	0.0085	0.10
	Riz mi-glacé	Oct. 1	9.1120	7.4342	81.59	0.1279	1.40	0.0295	0.32	0.1952	2.14	0.6660	7.31	0.4240	4.66	0.0106	0.12
	Half-pol. rice	2	8.5224	7.3086	85.76	0.2138	2.51	0.0242	0.28	0.2161	2.56	0.6431	7.55	0.4211	4.94	0.0090	0.16
		Moy-Aver	8.8172	7.3714	83.68	0.1709	1.96	0.0269	0.30	0.2067	2.35	0.6546	7.43	0.4226	4.80	0.0098	0.14
Konoike	Riz glacé	Oct. 3	8.7368	7.0447	80.63	0.1991	2.28	0.0242	0.28	0.0522	0.60	0.7002	8.01	0.4364	4.99	0.0064	0.06
	à 70 %	4	8.6832	7.4517	85.82	0.1991	2.29	0.0134	0.15	0.1438	1.66	0.5517	6.35	0.4428	5.10	0.0066	0.08
	70% pol. rice	Moy-Aver	8.7100	7.2482	83.23	0.1991	2.29	0.0188	0.22	0.0979	1.13	0.6260	7.18	0.4396	5.05	0.0065	0.07
	Riz glacé	Sept. 29	10.0880	9.0939	90.15	0.2433	2.41	0.0279	0.28	0.2056	2.04	0.6089	6.04	0.4704	4.66	0.0113	0.11
	à 70 %	30	10.5056	8.8210	83.96	0.2285	2.18	0.0242	0.23	0.2382	2.27	0.7117	6.77	0.4779	4.55	0.0077	0.07
	70% pol. rice	Moy-Aver	10.2968	8.9575	87.06	0.2359	2.30	0.0261	0.26	0.2219	2.16	0.6603	6.41	0.4742	4.61	0.0095	0.15
	Riz mi-glacé	Oct. 1	9.2621	7.4329	80.25	0.1384	1.49	0.0188	0.29	0.1217	1.32	0.6895	7.44	0.4817	5.20	0.0065	0.07
	Half-pol. rice	2	10.2912	7.8729	76.50	0.2310	2.24	0.0255	0.25	0.1883	1.83	0.7117	6.91	0.4741	4.61	0.0114	0.11
		Moy-Aver	9.7767	7.6529	78.38	0.1847	1.87	0.0222	0.27	0.1550	1.58	0.7006	7.18	0.4779	4.91	0.0089	0.14
	Riz glacé	Oct. 3	8.9512	6.1085	68.24	0.1427	1.59	0.0201	0.22	0.0776	0.87	0.6797	7.59	0.4596	5.13	0.0072	0.08
	à 70 %	4	10.4520	8.8952	85.11	0.1893	1.81	0.0177	0.17	0.2510	2.40	0.3918	3.75	0.4428	4.24	0.0134	0.13
	70% pol. rice	Moy-Aver	9.7016	7.5019	76.67	0.1660	1.70	0.0189	0.20	0.1643	1.64	0.5358	5.67	0.4512	4.69	0.0103	0.11

The Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Sugimoto			Inoue			Ishibashi		
		SO_3 (g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz glacé à 70% 70% pol. rice	Sept. 29	1.7515	1.4890	21.492	1.7207	1.8367	19.502	1.5259	1.4286	19.900
	30	1.7899	1.6531	23.382	1.6871	2.2039	25.273	1.9154	1.6938	27.064
	Moyenne —Aver.	1.7707	1.5711	22.437	1.7039	2.0203	22.388	1.7207	1.5112	23.482
Riz mi-glacé Half-pol. rice	Oct. 1	1.9374	1.8776	23.581	1.7358	1.9592	23.382	1.6735	1.7551	24.278
	2	1.9504	1.7959	26.069	1.7179	1.8776	27.661	1.8730	1.7959	25.969
	Moyenne —Aver.	1.9467	1.8368	24.825	1.7269	1.9184	25.523	1.7733	1.7755	25.124
Riz glacé à 70% 70% pol. rice	Oct. 3	1.8311	1.6938	22.288	1.7735	1.8367	26.964	1.8292	1.6326	25.771
	4	1.8757	1.6734	17.333	1.7008	1.7552	13.134	1.7818	1.5919	12.139
	Moyenne — Aver.	1.8534	1.6836	19.816	1.7372	1.7955	20.049	1.8055	1.6123	18.955

Période Period	Date	Kayano			Konoike		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz glacé à 70% 70% pol. rice	Sept. 29	1.5122	1.3877	22.492	1.9806	1.8163	19.801
	30	1.7227	1.3877	23.880	1.9628	1.9388	24.775
	Moyenne — Aver.	1.6175	1.3877	23.186	1.9717	1.8776	22.288
Riz mi-glacé Half-pol. rice	Oct. 1	1.7708	1.7347	24.477	1.8658	1.9346	19.402
	2	1.6362	1.6938	25.771	2.0060	2.0041	28.059
	Moyenne — Aver.	1.7035	1.7143	25.124	1.9359	1.9694	23.731
Riz glacé à 70% 70% pol. rice	Oct. 3	1.7145	1.6326	25.771	1.7503	1.6122	26.168
	4	1.7133	1.4694	12.139	2.0656	1.7959	14.228
	Moyenne — Aver.	1.7139	1.5510	18.955	1.9079	1.7041	20.198

Sujets Subject	Période Period	Absorption d'azote Moyenne journalière N. intake Average per day		Azote trouvé dans l'urine Moyenne journalière N. in urine Average per day		Azote trouvé dans les selles Moyenne journalière N. in fæces Average per day		Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière Absorption Average per day			Pourcentage d'absorption % of absorption
		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake		Azote (gr.) Nitrogen (gms.)	Proteine (gr.) Protein (gms.)	Calories	
Sugimoto .	Riz glacé à 70% 70% pol. rice	12.5570	75.8563	9.7016	80.00	1.9505	16.07	+ 0.4849	10.1865	64.6656	265.129	83.93
	Riz mi-glacé Half-pol. rice	12.8619	80.3869	9.8624	76.68	2.3839	18.53	+ 0.6156	10.4780	65.4875	268.499	81.47
	Riz glacé à 70% 70% pol. rice	12.1370	75.8563	9.7820	80.59	1.7849	14.71	+ 0.5701	10.3521	64.7006	265.272	85.29
Inoue . . .	*Idem*	12.5575	78.4844	8.9244	71.07	2.0968	16.70	+ 2.5363	10.4607	65.3794	268.056	83.30
		13.5915	84.9369	9.1921	67.63	3.0558	22.48	+ 1.3436	10.5357	65.8451	269.965	77.52
		12.5575	78.4844	9.0045	71.71	2.3418	18.75	+ 1.2139	10.2157	63.8481	261.777	81.25
Ishibashi .	*Idem*	12.9780	81.1125	8.6812	66.89	2.0698	15.95	+ 2.2270	10.9082	68.1763	279.523	84.05
		13.8347	86.4669	8.8976	64.31	2.5131	18.17	+ 2.4240	11.3216	70.7600	290.116	81.83
		12.9780	81.1125	9.1924	70.82	1.8990	14.63	+ 1.8866	11.0790	69.2438	283.900	85.37
Kayano . .	*Idem*	12.7678	79.7988	8.3614	65.49	1.7722	13.88	+ 2.6342	10.9956	68.7225	281.762	86.12
		13.5915	84.9369	8.8172	64.87	2.5702	18.91	+ 2.2041	11.0213	68.8831	282.421	81.09
		12.7678	79.7988	8.7100	68.22	2.2704	17.78	+ 1.7874	10.4974	65.6088	268.996	82.22
Konoike . .	*Idem*	12.5575	78.4844	10.2968	81.99	2.3351	18.59	— 0.0744	10.2224	63.8900	291.949	81.41
		13.5915	84.9369	9.7767	71.93	2.3061	16.97	+ 1.5087	11.2854	70.5338	289.189	83.03
		12.5575	78.4844	9.7016	77.25	1.6949	13.49	+ 1.1610	10.8626	67.8913	278.354	86.51

The Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets / Subject	Période / Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pour centage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Sugimoto	Riz glacé à 70% / 70% pol. rice	394.08	1.1899	0.30	392.84	1610.644	99.70
	Riz mi-glacé / Half pol. rice	365.54	2.3652	0.64	363.17	1488.997	99.36
	Riz glacé à 70% / 70% pol. rice	394.03	1.4048	0.36	392.63	1609.783	99.64
Inoue . .	*Idem*	422.09	1.5500	0.37	420.54	1724.314	99.63
		403.75	3.6198	0.89	400.13	1640.533	99.11
		422.09	2.0759	0.49	420.01	1722.041	99.51
Ishibashi.	*Idem*	450.15	1.5432	0.34	448.61	1839.301	99.66
		416.48	2.4085	0.58	414.07	1697.687	99.42
		450.15	1.3160	0.29	448.83	1840.203	99.71
Kayano .	*Idem*	436.12	1.3221	0.30	434.80	1782.680	99.70
		403.75	2.8965	0.71	400.85	1643.485	99.29
		436.12	1.5923	0.37	434.53	1781.573	99.63
Konoike .	*Idem*	422.09	1.5771	0.37	420.51	1724.091	99.63
		403.75	2.2855	0.56	401.46	1645.986	99.44
		422.09	1.5735	0.37	420.52	1724.132	99.63

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Sugimoto	Riz glacé à 70% 70% pol. rice	17.01	2.8691	16.81	14.14	131.502	83.19
	Riz mi-glacé Half-pol. rice	18.00	4.7222	26.23	13.28	123.504	73.77
	Riz glacé à 70% 70% pol. rice	17.01	3.1092	18.28	13.90	129.270	81.72
Inoue . .	*Idem*	17.36	2.6308	15.16	14.73	137.049	84.84
		18.66	5.6118	30.07	13.05	121.365	69.93
		17.36	3.3334	19.20	14.03	130.479	80.80
Ishibashi.	*Idem*	17.71	3.1025	17.52	14.61	135.873	82.48
		18.88	4.2106	22.30	14.67	136.431	77.70
		17.71	3.3507	18.92	14.36	133.548	81.08
Kayano .	*Idem*	17.54	2.3866	13.66	15.15	140.895	86.34
		18.66	4.4665	23.99	14.19	131.967	76.01
		17.54	3.8924	22.19	13.65	126.945	77.81
Konoike .	*Idem*	17.36	3.0289	17.45	14.33	133.269	82.55
		18.66	5.1517	27.60	13.51	125.643	72.40
		17.36	3.1433	18.11	14.22	132.216	81.89

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Sugimoto .	Riz glacé à 70% . . . 70% polished rice . .	26.95	3.1568	11.71	88.29
	Riz mi-glacé . . . . . Half-polished rice . .	27.17	4.9033	18.05	81.95
	Riz glacé à 70% . . . 70% polished rice . .	26.95	3.3906	12.58	87.42
Inoue. . .	*Idem*	27.12	2.6540	9.79	90.21
		27.46	4.8190	17.55	82.45
		27.12	3.4088	12.57	87.43
Ishibashi .	*Idem*	27.29	2.9852	10.93	89.07
		27.55	4.2248	15.33	84.67
		27.29	3.2715	11.98	88.02
Kayano .	*Idem*	27.21	2.5634	9.42	90.58
		27.46	5.2762	19.21	80.79
		27.21	3.7907	13.93	86.07
Konoike .	*Idem*	27.12	3.2332	11.92	88.08
		27.46	4.5952	16.73	83.27
		27.12	3.4576	12.74	87.26

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets / Subject	Période / Period	Absorption des calories Moyenne journalière — Calories intake Average per day: Calories totales / Total calories	Absorption: Par kg. du poids / Per kg. of body weight	Utilisation des calories — Caloric utilisation: Calories totales / Total calories	Utilisation: Par kg. du poids / Per kg. of body weight	% de la quantité de calories absorbée / % against calories intake
Sugimoto	Riz glacé à 70% / 70% pol. rice	2085.006	35.17	2007.275	33.86	96.27
	Riz mi-glacé / Half-pol. rice	1995.979	33.78	1881.000	31.84	94.25
	Riz glacé à 70 % / 70% pol. rice	2085.006	35.34	2004.325	33.97	96.12
Inoue	*Idem*	2214.082	39.80	2129.419	38.28	96.18
		2177.474	38.90	2031.863	36.29	93.04
		2214.082	39.82	2114.297	38.03	95.50
Ishibashi	*Idem*	2343.158	48.51	2254.697	46.68	96.23
		2237.945	46.16	2124.234	43.82	94.93
		2343.158	48.33	2257.651	46.57	96.36
Kayano	*Idem*	2278.668	47.97	2205.337	46.43	96.79
		2177.474	45.84	2057.873	43.32	94.50
		2278.668	47.97	2177.514	45.84	95.56
Konoike	*Idem*	2214.082	43.95	2119.309	42.09	95.99
		2177.474	43.12	2060.818	40.81	94.64
		2214.082	43.93	2134.732	42.35	96.40

IV. *Comparison of 70%-polished Rice with 50%-polished Rice.*

The percentages of digestibility and utilised calories were as follows:

Period	Total Nitrogen	Carbo-hydrate	Crude fat	Crude ash	Calories
Preparatory period (70%-polished rice)	83.762	99.664	83.880	89.246	96.292
Half-polished rice	80.988	99.324	73.962	82.626	94.272
70%-polished rice	84.128	99.624	80.660	87.240	95.988

The absolute digestible quantity of each constituent of the rice and the absolute output of each in the fæces were as shown in the following table:

		Riz glacé à 70 %, cuit Boiled 70 % polished rice	Riz mi-glacé cuit Boiled half-polished rice
Quantité fournie par 100 gr. de riz non glacé . . Amount obtained from 100 gms. of unpolished rice		239.55	242.76
Azote total Total nitrogen	Pourcentage — Percentage . . .	0.4205	0.4864
	Quantité — Amount	1.0181	1.1808
	Pourcentage de la digestibilité . . . % of digestibility	84.128	80.988
	Quantité totale utilisée . . . . . . Total amount utilised	0.8565	0.9563
	Total trouvé dans les selles . . . . Total in the fæces	0.1616	0.2245
Hydrates de carbone Carbohydrate	*Idem*	28.06 67.22 99.624 66.97 0.25	25.47 61.83 99.324 61.41 0.42
Graisse brute Crude fat	*Idem*	0.35 0.84 80.660 0.68 0.16	0.44 1.07 73.962 0.79 0.28
Cendres brutes Crude ash	*Idem*	0.17 0.41 87.240 0.36 0.05	0.19 0.46 82.606 0.38 0.08

Experiment V.

The Comparison of the Digestibility of Unpolished Rice and 70%-polished Rice.

In this experiment, five men were used as subjects and the following results were obtained.

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date Nov.	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	(%)	Azote de NH^3 Ammonia N. (g)	(%)	Azote de l'acide urique Uric acid N. (g)	(%)	Azote des bases puriques Purin base N. (g)	(%)	Azote des acides aminés Amino acid N. (g)	(%)	Azote de la créatinine Creatinin N. (g)	(%)	Azote de la créatine Creatin N. (g)	(%)
Sugimoto	Riz glacé	10	11.7859	9.0552	76.83	0.2069	1.76	0.0304	0.24	0.1856	1.58	0.5138	4.36	0.5376	4.57	0.0148	0.13
	à 70 %	11	10.7492	8.3869	78.02	0.2045	1.90	0.0290	0.28	0.0838	0.78	0.5974	5.56	0.5474	5.09	0.0206	0.19
	70% pol. rice	Moy-Aver	11.2186	8.7211	77.43	0.2057	1.83	0.0297	0.26	0.1347	1.18	0.5556	4.96	0.5425	4.83	0.0177	0.16
	Riz non glacé	12	9.0643	7.4274	81.94	0.1701	1.88	0.0225	0.22	0.1010	1.12	0.4718	5.20	0.5524	6.06	0.0156	0.17
	Unpol. rice	13	9.8211	8.0496	81.95	0.2094	2.13	0.0237	0.25	0.1766	1 80	0.6317	6.43	0.5484	5.58	0.0101	0.10
		Moy-Aver	9.4427	7.7385	81.95	0.1898	2.01	0.0231	0.24	0.1388	1.46	0.5518	5.82	0.5504	5.82	0.0129	0.14
	Riz glacé	14	10.6636	8.4860	79.59	0.1848	1.73	0.0242	0.24	0.1835	1.73	0.6888	6.46	0.5575	5.25	0.0159	0.13
	à 70 %	15	10.2780	8.1355	79.16	0.1897	1.85	0.0211	0.20	0.1489	1.45	0.7345	7.24	0.5524	5.37	0.0103	0.10
	70% pol. rice	Moy-Aver	10.4708	8.3108	79.38	0.1873	1.79	0.0227	0.22	0.1662	1.59	0.7117	6.85	0.5550	5.31	0.0131	0.12
Higuchi	Riz glacé	10	11.5146	8.0721	70.10	0.2808	2.44	0.0347	0.30	0.1678	1.46	0.7580	6.53	0.5018	4.36	0.0085	0.07
	à 70 %	11	11.2376	10.0021	89.01	0.2971	2.64	0.0376	0.33	0.1836	1.64	0.6226	5.54	0.5218	4.64	0.0134	0.12
	70% pol. rice	Moy-Aver	11.3761	9.0371	79.56	0.2890	2.54	0.0362	0.32	0.1757	1.55	0.6903	6.04	0.5118	4.50	0.0110	0.10
	Riz non glacé	12	9.6355	7.5302	78.25	0.2242	2.33	0.0361	0.39	0.1004	1.04	0.5974	6.20	0.4934	5.12	0.0084	0.09
	Unpol. rice	13	13.0991	10.7193	81.83	0.2684	1.88	0.0450	0.34	0.1973	1.51	0.6602	5.04	0.4976	3.65	0.0126	0.10
		Moy-Aver	11.3673	9.1248	80.04	0.2463	2.11	0.0406	0.37	0.1489	1.28	0.6288	5.62	0.4955	4.39	0.0105	0.10
	Riz glacé	14	13.8706	11.6693	84.13	0.2242	1.62	0.0319	0.23	0.1010	0.73	0.6888	4.97	0.4817	3.47	0.0117	0.09
	à 70 %	15	10.8689	8.1079	74.59	0.2324	2.10	0.0432	0.35	0.1418	1.31	0.6680	6.15	0.5524	5.08	0.0103	0.10
	70% pol. rice	Moy-Aver	12.3698	9.3886	79.36	0.2283	1.86	0.0376	0.29	0.1214	1.02	0.6784	5.56	0.5171	4.28	0.0110	0.10
Ishibashi	Riz glacé	10	9.5641	6.9042	72.19	0.2217	2.32	0.0255	0.27	0.1218	1.28	0.5552	5.80	0.4652	4.86	0.0109	0.11
	à 70 %	11	8.9073	7.1818	80.63	0.2217	2.49	0.0347	0.39	0.1238	1.39	0.7174	8.05	0.4527	5.08	0.0069	0.08
	70% pol. rice	Moy-Aver	8.2357	7.0430	76.41	0.2217	2.41	0.0301	0.32	0.1228	1.34	0.6363	6.93	0.4590	4.97	0.0089	0.10
	Riz non glacé	12	9.1214	7.7129	84.56	0.2094	2.30	0.0275	0.31	0.1170	1.29	0.7574	8.30	0.4652	5.10	0.0072	0.08
	Unpol. rice	13	8.4789	6.1365	72.37	0.1848	2.18	0.0261	0.33	0.1766	2.08	0.7916	9.34	0.4395	5.18	0.0099	0.12
		Moy-Aver	8.8002	6.9247	78.47	0.1971	2.24	0.0268	0.32	0.1468	1.69	0.7745	8.82	0.4524	5.14	0.0086	0.10

(Continuation.)

Sujets Subjects	Période Period	Date	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
		Nov.	(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Ishibashi	Riz glacé	14	9.6069	7.6844	79.99	0.1848	1 92	0.0205	0.21	0.0745	0.78	0.9002	9.37	0.4596	4.89	0.0108	0.11
	à 70 %	15	10.5636	7.6844	72.74	0.2168	2.05	0.0347	0.33	0.1112	1.05	0.9002	8.52	0.4596	4.35	0.0145	0.14
	70% pol. rice	Moy-Aver	10.0853	7.6844	76 37	0.2008	1.99	0.0276	0.27	0.0929	0.92	0.9002	8.95	0.4596	4.62	0.0127	0.13
Kayano	Riz glacé	10	8.1652	6.0872	74.55	0.1822	2.23	0.0325	0.40	0.0771	0.95	0.4581	5.61	0.4588	5.62	0.0063	0.08
	à 70 %	11	9.0177	7.2108	79.96	0.2215	2.46	0.0307	0.34	0.1258	1.40	0.6149	6.82	0.4674	5.18	0.0066	0.07
	70% pol. rice	Moy-Aver	8.5915	6.6490	77.26	0.2019	2.35	0.0316	0.37	0.1015	1.18	0.5365	6.32	0.4631	5.40	0.0065	0.08
	Riz non glacé	12	8.6645	7.1074	82.03	0.2242	2.59	0.0354	0.41	0.0734	0.85	0.6203	7.15	0.4596	5.30	0.0107	0.12
	Unpol. rice	13	9.3499	7.8100	83.53	0.2488	2.66	0.0387	0.41	0.1331	1.43	0.6431	6.88	0.4494	4.91	0.0068	0.07
		Moy-Aver	9.0072	7.4587	82.78	0.2365	2.63	0.0371	0.41	0.1033	1.14	0.6317	7.02	0.4545	5.11	0.0088	0.10
Yamamoto	Riz glacé	14	10.0496	8.3182	82.77	0.2119	2.11	0.0311	0.31	0.1466	1.46	0.7688	7.65	0.4562	4.54	0.0107	0.11
	à 70 %	15	10.0496	8.0275	79.88	0.2094	2.08	0.0354	0.35	0.1253	1.25	0.6888	6.85	0.4460	4.44	0.0067	0.07
	70% pol. rice	Moy-Aver	10.0496	8.1729	81.33	0.2107	2.10	0.0333	0.33	0.1360	1.36	0.7288	7.25	0.4511	4.49	0.0087	0.09
	Riz glacé	10	9.2974	5.8913	63.36	0.2168	2.33	0.0205	0.22	0.1088	1.17	0.5885	6.33	0.4527	4.87	0.0069	0.07
	à 70 %	11	8.9358	7.6992	86.22	0.2096	2.35	0.0391	0.44	0.1010	1.13	0.5997	6.71	0.4703	5.36	0.0105	0.12
	70% pol. rice	Moy-Aver	9.1166	6.7953	74.79	0.2132	2.34	0.0298	0.33	0.1049	1.15	0.5941	6.52	0.4615	5.12	0.0087	0.10
	Riz non glacé	12	7.1531	5.5425	77.48	0.2020	2.82	0.0347	0.49	0.1033	1.45	0.5289	7.39	0.4596	6.44	0.0072	0.10
	Unpol. rice	13	9.3927	7.0047	74.69	0.2168	2.31	0.0326	0.35	0.1491	1.59	0.7231	7.70	0.4652	4.95	0.0109	0.12
		Moy-Aver	8.2929	6.2736	76.09	0.2094	2.62	0.0337	0.42	0.1262	1.52	0.6260	7.55	0.4624	5.70	0.0091	0.11
	Riz glacé	14	8.3508	6.4690	77.47	0.1947	2.44	0.0305	0.37	0.0829	1.02	0.7231	8.66	0.4704	5.75	0.0113	0.14
	à 70 %	15	8.2652	5.8142	70.35	0.1827	2.21	0.0305	0.37	0.0941	1.14	0.7122	8.62	0.4898	5.93	0.0072	0.09
	70% pol. rice	Moy-Aver	8.3080	6.1416	73.91	0.1887	2.33	0.0305	0.37	0.0895	1.08	0.7177	8.64	0.4801	5.84	0.0093	0.12

The Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Sugimoto			Higuchi			Ishibashi		
		SO_3(g)	P_2O_5(g)	NaCl(g	SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz glacé	Nov. 10	2.0779	2.0041	27.0	2.1644	2.1632	25.4	1.9511	1.5307	27.1
à 70%	11	2.1651	2.0816	24.2	2.2555	2.5042	27.1	1.6759	1.8571	22.3
70% pol. rice	Moyenne – Aver.	2.1215	2.0429	25.6	2.2100	2.3337	26.3	1.8135	1.6939	24.7
	12	1.6183	1.4286	22.1	2.0560	2.1428	21.7	1.8039	1.7959	25.7
Riz non glacé	13	1.9559	1.9388	24.8	2.3934	2.5712	26.8	1.4467	1.7756	22.9
Unpol. rice	Moyenne – Aver.	1.7871	1.6837	23.5	2.2297	2.3570	24.3	1.6253	1.7858	24.3
Riz glacé à	14	1.9408	1.9999	26.6	2.2693	2.3060	27.3	1.8197	1.8367	28.0
70%	15	2.0560	2.0041	27.1	2.3983	2.2660	25.1	1.9966	1.9387	26.8
70% pol. rice	Moyenne – Aver.	1.9984	2.0020	26.9	2.3338	2.2860	26.2	1.9082	1.8877	27.4

Période Period	Date	Kayano			Yamamoto		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz glacé à	Nov. 10	1.6568	0.9370	25.9	1.5636	1.8367	25.1
70%	11	1.7029	1.3592	23.2	1.6967	2.0090	25.3
70% pol. rice	Moyenne – Aver.	1.6799	1.1481	24.6	1.6302	1.9229	25.2
	12	1.8757	1.7756	26.9	1.4992	1.9796	24.0
Riz non glacé	13	1.7776	2.2081	17.1	1.7200	2.2856	28.2
Unpol. rice	Moyenne – Aver.	1.8267	1.9919	22.0	1.6096	2.1326	26.1
Riz glacé à	14	1.8928	1.9387	26.3	1.5897	1.9183	28.0
70%	15	1.9360	1.9796	25.0	1.4141	1.6326	21.6
70% pol. rice	Moyenne – Aver.	1.9144	1.9592	25.7	1.5019	1.7755	24.8

Nitrogen Balance: the Digestibility and Utilisation, and Caloric Value.

Sujets / Subject	Période / Period	Absorption d'azote Moyenne journalière — N. intake Average per day: Azote (gr.) Nitrogen (gms.)	Absorption d'azote Moyenne journalière — N. intake Average per day: Proteïne (gr.) Protein (gms.)	Azote trouvé dans l'urine Moyenne journalière — N. in urine Average per day: Quantité (gr.) Quantity (gms.)	Azote trouvé dans l'urine Moyenne journalière — N. in urine Average per day: % de la quantité absorbée % against intake	Azote trouvé dans les selles Moyenne journalière — N. in fæces Average per day: Quantité (gr.) Quantity (gms.)	Azote trouvé dans les selles Moyenne journalière — N. in fæces Average per day: % de la quantité absorbée % against intake	Balance de l'azote / Nitrogen balance	Absorption Moyenne journalière — Absorption Average per day: Azote (gr.) Nitrogen (gms.)	Absorption Moyenne journalière — Absorption Average per day: Proteïne (gr.) Protein (gms.)	Absorption Moyenne journalière — Absorption Average per day: Calories	Pourcentage d'absorption / % of absorption
Sugimoto .	Riz glacé à 70% 70% pol. rice	12.5575	78.4844	11.2186	89.34	2.3311	18.56	— 0.9922	10.2264	63.9150	262.052	81.44
	Riz non glacé Unpolished rice	12.4905	78.0659	9.4427	75.60	3.1893	25.53	— 0.1415	9.3012	58.1325	238.343	74.47
	Riz glacé à 70% 70% pol. rice	12.5575	78.4844	10.4708	83.38	1.9063	15.18	+ 0.1804	10.6512	66.5700	272.937	84.82
Higuchi . .	*Idem*	12.9780	81.1125	11.3761	87.66	3.2128	24.75	— 1.6109	9.7652	61.0325	250.233	75.25
		12.9884	81.1775	11.3673	87.59	3.4312	26.41	— 1.8101	9.5572	59.7325	244.903	73.59
		13.3985	83.7406	12.3698	92.32	2.4974	18.64	— 1.4687	10.9011	68.1319	279.341	81.36
Ishibashi .	*Idem*	12.5575	78.4844	9.2357	73.54	2.1877	17.42	+ 1.1341	10.3698	64.8113	265.726	82.58
		13.4863	84.2894	8.8002	65.25	4.3622	32.34	+ 0.3239	9.1241	57.0256	233.805	67.66
		12.5575	78.4844	10.0853	80.31	1.9810	15.77	+ 0.4912	10.5765	66.1031	271.023	84.23
Kayano . .	*Idem*	13.6088	85.0550	8.5915	63.13	2.9072	21.36	+ 2.11 01	10.7016	66.8850	274.229	78.64
		13.7353	85.8456	9.0072	65.57	3.8625	28.12	+ 0.8656	9.8728	61.7050	252.991	71.88
		12.5575	78.4844	10.0496	80.00	1.8663	14.86	+ 0.6416	10.6912	66.8200	273.962	85.14
Yamamoto .	*Idem*	12.7678	79.7988	9.1166	71.40	2.1998	17.23	+ 1.4514	10.5680	66.0500	270.805	82.77
		13.7353	85.8456	8.2929	60.37	4.3337	31.55	+ 1.1087	9.4016	58.7600	240.916	68.45
		13.3985	83.7406	8.3080	62.01	2.9986	22.38	+ 2.0919	10.3999	64.9994	266.498	77.62

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Sugimoto	Riz glacé à 70% 70% pol. rice	422.09	1.4363	0.34	420.65	1724.665	99.66
	Riz non glacé Unpolished rice	311.47	5.1422	1.65	306.33	1255.953	98.35
	Riz glacé à 70% 70% pol. rice	422.09	1.5053	0.35	420.58	1724.378	99.64
Higuchi .	*Idem*	450.15	2.0095	0.44	448.14	1837.374	99.56
		334.08	3.7644	1.13	330.32	1354.312	98.87
		478.21	2.0240	0.42	476.19	1952.379	99.58
Ishibashi.	*Idem*	422.09	1.5919	0.37	420.50	1724.050	99.63
		356.69	4.7172	1.32	351.97	1443.077	98.68
		422.09	1.9281	0.45	420.16	1722.656	99.55
Kayano .	*Idem*	492.24	2.6044	0.53	489.64	2007.524	99.47
		368.00	5.0661	1.38	362.93	1488.013	98.62
		422.09	1.9137	0.45	420.18	1722.778	99.55
Yamamoto	*Idem*	436.12	2.4668	0.56	433.65	1777.965	99.44
		368.00	7.4378	2.02	360.56	1478.296	97.98
		478.21	7.4378	0.55	475.58	1949.878	99.45

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Sugimoto	Riz glacé à 70 % 70% pol. rice	17.36	3.5950	20.71	13.76	127.968	79.29
	Riz non glacé Unpol. rice	20.56	9.9752	48.51	10.58	98.394	51.49
	Riz glacé à 70% 70% pol. rice	17.36	2.8381	16.35	14.52	135.036	83.65
Higuchi .	*Idem*	17.71	4.0977	23.19	13.19	126.573	76.81
		21.30	9.6889	45.49	11.61	107.973	54.51
		18.06	4.4452	24.65	13.61	126.573	75.35
Ishibashi	*Idem*	17.36	3.0826	17.76	14.28	132.804	82.24
		22.04	8.2539	37.45	13.79	128.247	62.55
		17.36	2.6802	15.44	14.68	136.524	84.56
Kayano .	*Idem*	18.24	3.8287	20.99	14.41	134.013	79.01
		22.41	10.047	44.65	12.41	115.413	55.35
		17.36	3.2583	18.77	14.10	131.130	81.23
Yamamoto	*Idem*	17.36	1.9770	11.38	15.56	144.708	88.62
		22.41	11.7534	52.44	10.66	99.138	47.56
		18.06	3.7288	20.64	14.33	133.269	79.36

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Pourcentage d'absorption % of absorption
Sugimoto .	Riz glacé à 70% . . . 70% polished rice . .	27.12	4.0371	11.46	88.54
	Riz non glacé . . . . Unpolished rice . . .	27.78	6.5761	20.16	79.84
	Riz glacé à 70% . . . 70% polished rice . .	27.12	3.7838	10.05	89.95
Higuchi .	*Idem*	27.29	4.0371	14.79	85.21
		28.05	6.5761	23.44	76.56
		27.46	3.7838	13.78	86.22
Ishibashi .	*Idem*	27.12	3.1547	11.63	88.37
		28.29	6.6292	23.43	76.57
		27.12	2.5525	9.41	90.59
Kayano .	*Idem*	27.55	3.9929	14.49	85.51
		28.43	7.7138	27.13	72.87
		27.12	3.3725	12.44	87.56
Yamamoto	*Idem*	27.21	2.9836	10.96	89.04
		28.43	7.4949	26.36	73.64
		27.46	3.8227	13.92	86.08

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Caloric utilisation		% de la quantité de calories absorbée % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Sugimoto .	Riz glacé à 70% . 70% pol. rice . .	2214.082	37.25	2114.685	35.58	95.52
	Riz non glacé . . Unpolished rice .	1788.584	30.09	1591.690	26.77	88.96
	Riz glacé à 70% . 70% pol. rice . .	2214.082	37.21	2132.351	35.84	96.32
Higuchi .	*Idem*	2343.158	39.06	2214.180	36.91	94.49
		1900.924	31.80	1707.188	28.56	89.81
		2472.234	41.32	2358.293	39.40	95.35
Ishibashi .	*Idem*	2214.082	45.51	2122.580	43.63	95.87
		2013.266	41.40	1805.129	37.12	98.66
		2214.082	45.48	2130.203	43.78	96.04
Kayano .	*Idem*	2512.547	51.75	2415.766	49.76	96.15
		2069.449	43.02	1856.417	38.59	89.70
		2214.082	45.69	2127.870	43.92	96.12
Yamamoto	*Idem*	2278.668	48.81	2193.478	46.99	96.27
		2069.449	44.60	1818.350	39.19	87.87
		2472.234	53.07	2349.645	50.44	95.04

V. *Comparison of 70%-polished Rice with unpolished Rice.*

The percentages of digestibility and utilised calories were as follows:

	Total Nitrogen	Carbo-hydrate	Crude fat	Crude ash	Calories
Preparatory period (70%-polished rice) .	80.136	99.552	81.194	87.334	95.660
Unpolished rice period .	71.210	98.500	54.292	75.896	89.200
70%-polished rice period	82.634	99.554	80.830	88.080	95.774

The absolute digestible quantity of each constituent of the rice and the absolute output of each in the fæces were as shown in the following table:

		Riz glacé à 70 %, cuit Boiled 70 % polished rice	Riz non glacé cuit Boiled unpolished rice
Quantité fournie par 100 gr. de riz non glacé . . Amount obtained from 100 gms. of unpolished rice. .		239.55	267.06
Azote total Total nitrogen	Pourcentage — Percentage . . .	0.4205	0.4979
	Quantité — Amount	1.0181	1.3297
	Pourcentage de digestibilité . . . . % of digestibility	82.634	71.210
	Quantité totale utilisé . . . . . . Total amount utilised	0.8413	0.9468
	Total trouvé dans les selles . . . . Total in the fæces	0.1768	0.3829
Hydrates de carbone Carbohydrate	*Idem*	28.06 67.22 99.554 66.92 0.30	22.61 60.38 98.500 59.47 0.91
Graisse brute Crude fat	*Idem*	0.35 0.84 80.830 0.68 0.16	0.74 1.98 54.292 1.07 0.91
Cendres brutes Crude ash	*Idem*	0.17 0.41 88.080 0.36 0.05	0.27 0.72 75.986 0.55 0.17

Experiment VI.

The Comparison of the Digestibility of Unpolished Rice and Half-polished Rice.

In this experiment, five men were used as subjects and the following results were obtained.

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjetes	Période Period	Date	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
		Nov.	(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Narita	Riz mi-glacé	24	7.7564	6.3479	81.84	0.1744	2.25	0.0225	0.29	0.0720	0.93	0.4378	5.64	0.3721	4.80	0.0114	0.15
		25	7.6996	6.3482	82.44	0.1516	1.97	0.0254	0.33	0.1135	1.47	0.4946	6.42	0.3838	5.24	0.0100	0.13
	Half-pol. rice	Moy-Aver	7.7280	6.3481	82.14	0.1630	2.11	0.0240	0.31	0.0928	1.20	0.4662	6.03	0.3780	5.02	0.0107	0.14
	Riz non glacé	26	7.5850	6.3756	84.00	0.1516	2.00	0.0204	0.28	0.1168	1.54	0.5403	7.10	0.3811	5.02	0.0074	0.10
		27	8.0419	6.4441	80.13	0.1401	1.74	0.0247	0.30	0.1290	1.60	0.7459	9.28	0.3740	4.65	0.0070	0.09
	Unpol. rice	Moy-Aver	7.8135	6.4099	82.07	0.1459	1.87	0.0226	0.29	0.1229	1.57	0.6431	8.19	0.3776	4.84	0.0072	0.10
Higuchi	Riz mi-glacé	28	8.9558	6.6703	74.48	0.1744	1.95	0.0210	0.24	0.1444	1.61	0.9630	10.75	0.3860	4.31	0.0101	0.11
		29	7.2994	5.9934	82.19	1.1401	1.82	0.0210	0.28	0.0692	0.95	0.9858	13.64	0.3721	5.10	0.0114	0.16
	Half-pol. rice	Moy-Aver	8.1276	6.3319	78.34	0.1573	1.89	0.0210	0.26	0.1068	1.28	0.9744	12.20	0.3791	4.71	0.0108	0.14
	Riz mi-glacé	24	10.9549	9.2037	84.01	0.3003	2.74	0.0404	0.37	0.0885	0.85	0.4378	4.00	0.5236	4.78	0.0140	0.13
		25	12.0515	9.2517	76.77	0.2824	2.34	0.0404	0.37	0.1465	1.21	0.6040	5.01	0.5263	4.37	0.0113	0.09
	Half-pol. rice	Moy-Aver	11.5032	9 2277	80.39	0.2914	2.54	0.0404	0.37	0.1175	1.03	0.5209	4.51	0.5250	4.58	0.0127	0.11
	Riz non glacé	26	10.5549	8.0622	76.38	0.2574	2.44	0.0446	0.42	0.1258	1.19	0.7054	6.68	0.5282	5.00	0.0095	0.09
		27	12.6570	11.0290	87.14	0.2459	1.94	0.0375	0.30	0.1888	1.06	0.6546	5.18	0.5060	4.00	0.0088	0.06
	Unpol. rice	Moy-Aver	11.6060	9.5456	81.76	0.2517	2.19	0.0411	0.36	0.1573	1.13	0.6800	5.93	0.5172	4.50	0.0092	0.08
Ishibashi	Riz mi-glacé	28	9.0129	7.7075	84.31	0.2660	2.95	0.0347	0.39	0.1513	1.68	1.0201	11.32	0.5236	5.81	0.0140	0.16
		29	11.5475	8.4473	73.15	0.2705	2.34	0.0405	0.35	0.1601	1.39	0.9085	7.87	0.5095	5.93	0.0121	0.11
	Half-pol. rice	Moy-Aver	10.2802	8.0774	78.73	0.2683	2.65	0.0376	0.37	0.1557	1.54	0.9643	9.60	0.5116	5.37	0.0131	0.14
	Riz mi-glacé	24	10.4979	8.3517	79.56	0.2259	2.15	0.0275	0.27	0.1456	1.40	0.5472	5.21	0.4704	4.48	0.0113	0.11
		25	10 4979	7.9647	75.87	0.1773	1.69	0.0350	0.33	0.1680	1.66	0.9058	8.63	0.4895	4.66	0.0123	0.12
	Half-pol. rice	Moy-Aver	10.4979	8.1582	77.72	0.2016	1.92	0.0313	0.30	0.1568	1.53	0.7265	6.42	0.4800	4.57	0.0118	0.12
	Riz non glacé	26	10.0409	7.4354	74.06	0.1659	1.65	0.0287	0.29	0.1682	1.68	0.6660	6.63	0.4898	4.88	0.0072	0.07
		27	9.7555	8.4268	86.48	0.1830	1.99	0.0261	0.27	0.1416	1.45	0.8259	8.46	0.4652	4.77	0.0109	0.11
	Unpol. rice	Moy-Aver	9.8982	7.9311	80.27	0.1745	1.82	0.0274	0.28	0.1549	1.57	0.7460	7.55	0.4775	4.83	0.0091	0.14

(Continuation.)

Sujets Subjects	Période Period	Date	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
		Nov.	(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%	(g)	(%)
Ishibashi	Riz mi-glacé	28	10.9549	8.9940	83.30	0.2202	2.01	0.0325	0.30	0.1513	1.39	0.6201	5.66	0.4527	4.13	0.0141	0.13
		29	9.8987	8.3783	84.64	0.2002	2.02	0.0347	0.35	0.0719	1.23	1.0201	9.33	0.4652	3 69	0.0109	0.11
	Half-pol. rice	Moy-Aver	10.4268	8.6862	83.97	0.2102	2.02	0.0336	0.33	0.1116	1.06	0.8201	7.50	0.4590	3.91	0.0125	0.12
Kayano	Riz mi-glacé	24	10.9263	9.0326	82.67	0.2288	2.09	0.0201	0.26	0.1626	1.50	0.4946	4.52	0.4560	4.16	0.0107	0.10
		25	9.2414	7.0279	76.05	0.2166	2.34	0.0261	0.29	0.1861	2.01	0.6431	6.96	0.4741	5.13	0.0076	6.08
	Half-pol. rice	Moy-Aver	10.0839	8.0303	78.36	0.2227	2.22	0.0276	0.28	0.1744	1.76	0.5689	5.74	0.4651	4.65	0.0092	0.09
	Riz non glacé	26	9.5850	7.7187	80.52	0.1887	1.96	0.0217	0.21	0.0958	1.00	0.8487	8.85	0.4596	4.79	0.0107	0.11
		27	9.4698	7.6669	80.96	0.1830	2.00	0.0205	0.21	0.1287	1.36	0.5632	5.95	0.4560	4.81	0.0107	0.11
	Unpol. rice	Moy-Aver	9.5274	7.6928	80.74	0.1859	1.98	0.0211	0.21	0.1123	1.18	0.7060	7.40	0.4578	4.80	0.0107	0.11
Yamamoto	Riz mi-glacé	28	9.9839	7.6584	76.81	0.2316	2.32	0.0205	0.20	0.1560	1.57	0.5974	5.98	0.4779	4.79	0.0155	0.16
		29	9.4127	7.8893	83.82	0.2002	2.29	0.0276	0.30	0.1280	1.36	0.7088	7.53	0.4704	5.00	0.0113	0.12
	Half-pol. rice	Moy-Aver	9.6983	7.7739	80.32	0.2159	2.31	0.0241	0.25	0.1420	1.47	0.6531	6.76	0.4742	4.90	0.0134	0.14
	Riz mi-glacé	24	9 2128	7.6504	83.03	0.1830	1.12	0.0205	0.22	0.0769	0.83	0.4204	4.56	0.4817	5.09	0.0117	0.13
		25	7.7564	6.5880	84.93	0.2030	2.62	0.0237	0.30	0.0613	0.86	0.5974	7.70	0.5018	6.47	0.0129	0.17
	Half-pol. rice	Moy-Aver	8.4846	7.1192	83.98	0.1930	1.87	0.0221	0.26	0.0691	0.85	0.5089	6.13	0.4918	5.78	0.0123	0.15
	Riz non-glacé	26	7.8135	5.9511	76.17	0.1716	2.20	0.0261	0.34	0.0942	1.22	0.6431	8.23	0.4817	7.16	5.0117	0.15
		27	9.1261	7.0890	77.68	0.1945	2.13	0.0205	0.22	0.1623	1.78	0.6660	7.30	0.4895	5.36	0.0123	0.14
	Unpol. rice	Moy-Aver	8.4698	6.5201	76.93	0.1831	2.17	0.0233	0.28	0.1283	1.50	0.6546	7.77	0.4856	6.76	0.0120	0.15
	Riz mi-glacé	28	8.6702	6.6676	76.90	0.1973	2.28	0.0211	0.25	0.1204	1.14	0.7002	8.08	0.5018	5.79	0.0085	0.10
		29	10.8406	8.5229	78.62	0.2774	2.56	0.0276	0.24	0.1078	0.99	0.8031	7.41	0.5147	4.75	0.0179	0.17
	Half-pol. rice	Moy-Aver	9.7554	7.5953	77.76	0.2374	2.42	0.0244	0.25	1.1141	1.07	0.7517	7.75	0.5083	5.27	0.0132	0.14

The Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Narita			Higuchi		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz mi-glacé Half-pol. rice	Nov. 24	1.4278	1.4000	21.59	2.1363	2.3636	20.40
	25	1.5156	1.4545	25.87	2.1079	2.8181	27.86
	Moyenne – Aver.	1.4717	1.4273	23.73	2.1221	2.5909	24.13
Riz non glacé Unpol. rice	26	1.3579	1.4364	23.68	2.0656	2.4364	21.49
	27	1.4045	1.4745	26.46	2.0848	2.4183	27.25
	Moyenne – Aver.	1.3812	1.4455	25.07	2.0752	2.4274	24.37
Riz mi-glacé Half-pol. rice	28	1.5581	1.4726	26.46	2.0416	2.4545	22.88
	29	1.4271	1.1818	24.44	1.9101	2.5000	28.46
	Moyenne – Aver.	1.4926	1.3272	25.45	1.9759	2.4773	25.67

Période Period	Date	Ishibashi			Kayano			Yamamoto		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz mi-glacé Half-pol. rice	Nov. 24	1.7604	1.6182	27.46	1.7961	1.6182	26.57	1.7199	2.2182	21.89
	25	1.9134	1.8291	16.52	1.6905	1.7654	26.06	1.3665	1.9818	26.06
	Moyenne – Aver.	1.8369	1.7237	21.99	1.7433	1.6918	26.32	1.5432	2.1000	23.98
Riz non glacé Unpol. rice	26	1.7589	1.7091	22.29	1.6850	1.6545	24.68	1.3853	1.8000	22.69
	27	1.6699	1.8181	25.87	1.6219	2.0747	26.46	1.5314	2.2727	25.68
	Moyenne – Aver.	1.7144	1.7636	24.08	1.6535	1.8646	25.57	1.4584	2.0364	24.19
Riz mi-glacé Half-pol. rice	28	1.2053	1.6182	26.67	1.7906	1.8181	23.88	1.6006	1.8727	27.25
	29	1.7084	1.7273	24.44	1.6041	1.6364	24.87	1.8400	2.1818	25.27
	Moyenne – Aver.	1.8069	1.6728	25.56	1.6974	1.7273	24.38	1.7203	2.0273	26.26

Sujets Subject	Période Period	Absorption d'azote Moyenne journalière N. intake Average per day		Azote trouvé dans l'urine Moyenne journalière N. in urine Average per day		Azote trouvé dans les selles Moyenne journalière N. in fæces Average per day		Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière Absorption Average per day			Pourcentage d'absorption % of absorption
		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	
Narita . . .	Riz mi-glacé Half-pol. rice	12.8619	80.3869	7.7280	60.08	2.7052	21.03	+ 2.4287	10.1567	63.4794	260.266	78.97
	Riz non glacé Unpolished rice	13.2374	82.7338	7.8135	59.02	2.8651	21.65	+ 2.5588	10.3723	64.8269	265.790	78.35
	Riz mi-glacé Half-pol. rice	13.5915	48.9369	8.1276	59.79	2.4287	17.87	+ 3.0352	11.1628	69.7675	286.047	82.13
Higuchi . .	*Idem*	14.3211	89.5069	11.5032	80.32	2.9188	20.38	— 0.1009	11.4023	71.2644	292.184	79.62
		12.9884	81.1775	11.6060	89.35	2.9165	22.45	— 1.5341	10.0719	62.9494	258.093	77.55
		14.8075	92.5409	10.2802	69.43	2.1404	14.45	+ 2.3869	12.6671	79.1694	324.595	85.55
Ishibashi .	*Idem*	12.3755	77.3469	10.4979	84.83	2.0691	16.72	— 0.1915	10.3064	64.4150	264.102	83.28
		12.4905	78.0659	9.8982	79.24	3.2970	26.39	— 0.0747	9.1935	57.4594	235.584	73.61
		12.3755	77.3469	10.4268	84.25	1.8934	15.30	+ 0.0553	10.4821	65.5131	268.604	84.70
Kayano . .	*Idem*	12.8619	80.3869	10.0839	78.41	2.0562	16.00	— 0.7218	10.8057	67.5356	276.896	84.00
		12.2416	75.9475	9.5274	77.82	2.9852	24.38	— 0.2710	9.2564	57.8525	237.195	75.62
		12.8619	80.3869	9.6983	75.41	2.4089	18.73	+ 0.7547	10.4530	65.3313	267.858	81.27
Yamamoto .	*Idem*	12.8619	80.3869	8.4846	65.97	1.9648	15.27	+ 2.4125	10.8971	68.1069	279.238	84.73
		12.7395	79.6219	8.4698	66.48	3.4434	27.03	+ 0.8263	9.2961	58.1006	238.212	72.97
		12.8619	80.3869	9.7554	75.85	2.4660	19.17	+ 0.6405	10.3959	64.9744	266.395	80.83

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Narita .	Riz mi-glacé Half-pol. rice	365.54	2.6690	0.73	362.87	1487.767	99.27
	Riz non glacé Unpolished rice	345.39	3.7656	1.09	341.62	1400.642	98.91
	Riz mi-glacé Half-pol. rice	403.75	2.6486	0.65	401.10	1644.510	99.35
Higuchi .	*Idem*	441.95	3.1181	0.70	438.83	1799.203	99.30
		334.08	3.9571	1.18	330.12	1353.492	98.82
		468.42	2.6159	0.55	464.80	1905.680	99.45
Ishibashi	*Idem*	340.07	1.5521	0.47	338.52	1387.932	99.53
		311.47	4.8609	1.56	306.61	1257.101	98.44
		340.07	2.6752	0.78	337.39	1383.299	99.22
Kayano	*Idem*	365.54	2.2614	0.62	363.28	1489.448	99.38
		300.17	4.3639	1.45	295.81	1212.821	98.55
		365.54	2.6924	0.74	362.85	1487.685	99.26
Yamamoto	*Idem*	365.54	2.7251	0.74	362.81	1487.521	99.26
		322.78	5.4843	1.73	317.30	1300.930	98.27
		365.54	4.4033	1.20	361.14	1480.674	98.80

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Narita .	Riz mi-glacé Half-pol. rice	18.00	4.4277	24.60	13.57	126.201	75.40
	Riz non glacé Unpolished rice	21.67	8.4100	38.81	13.26	123.318	61.19
	Riz mi-glacé Half-pol. rice	18.66	5.5155	29.56	13.14	122.202	70.44
Higuchi .	*Idem*	19.32	6.1228	31.69	13.20	122.760	68.31
		21.30	9.2548	43.45	12.05	112.065	56.55
		19.76	4.8462	24.52	14.91	138.663	75.48
Ishibashi	*Idem*	17.56	3.4995	19.93	14.06	130.758	80.07
		20.56	9.6984	47.17	10.86	100.998	52.83
		17.56	4.4395	25.27	13.12	122.016	74.73
Kayano .	*Idem*	18.00	3.5227	19.57	14.48	134.664	80.43
		20.19	8.9372	44.26	11.25	104.625	55.74
		18.00	6.2927	34.96	11.71	108.903	65.04
Yamamoto	*Idem*	18.00	4.0222	22.35	13.98	130.014	77.65
		20.93	8.4961	40.59	12.43	115.599	59.41
		18.00	5.2555	29.20	12.74	118.482	70.80

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Narita . .	Riz mi-glacé	27.17	4.4592	16.41	83.59
	Half-polished rice . .				
	Riz non glacé	28.29	6.3207	22.34	77.66
	Unpolished rice . . .				
	Riz mi-glacé	27.46	5.0277	18.31	81.69
	Half-polished rice . .				
Higuchi .	*Idem*	27.74	5.5187	19.60	80.10
		28.05	6.1621	21.96	78.04
		27.93	4.1369	14.81	85.19
Ishibashi .	*Idem*	26.98	3.3794	12.53	87.47
		27.78	7.3595	26.41	73.59
		26.98	3.6036	13.35	86.65
Kayano .	*Idem*	27.17	3.9306	14.46	85.54
		27.65	6.2399	22.56	77.44
		27.17	4.2848	15.77	84.23
Yamamoto	*Idem*	27.17	3.9885	14.64	85.36
		27.92	4.6144	16.53	83.47
		27.17	4.0108	14.76	85.24

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Caloric utilisation		% de la quantité de calories absorbées % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Narita . .	Riz mi-glacé . . Half-pol. rice . .	1995.979	45.75	1874.234	42.98	93.94
	Riz non glacé . . Unpolished rice .	1957.117	44.83	1789.750	41.00	91.45
	Riz mi-glacé . . Half-pol. rice . .	2177.474	49.83	2052.759	46.90	94.12
Higuchi .	*Idem*	2358.928	38.73	2214.147	36.35	93.85
		1900.924	31.40	1723.650	28.47	90.67
		2479.911	40.85	2368.938	39.02	95.52
Ishibashi .	*Idem*	1874.996	38.82	1782.792	36.91	95.08
		1788.584	37.05	1593.683	33.01	89.10
		1874.996	38.81	1773.919	36.70	94.56
Kayano .	*Idem*	1995.979	41.11	1901.008	39.06	95.01
		1730.127	35.78	1554.641	32.15	89.85
		1995.979	41.19	1864.446	38.48	93.42
Yamamoto	*Idem*	1995.979	43.01	1896.773	40.88	95.04
		1850.675	40.21	1654.741	35.97	89.45
		1995.979	43.11	1865.551	40.29	93.46

VI. *Comparison of 50%-polished Rice with unpolished Rice.*

The percentages of digestibility and utilised calories were as follows:

	Total Nitrogen	Carbo-hydrate	Crude fat	Crude ash	Calories
Preparatory period (half-polished rice) .	82.120	99.356	76.372	84.412	94.584
Unpolished rice period .	75.620	98.598	57.144	78.040	90.104
Half-polished rice period	82.896	99.216	71.298	84.600	94.216

The absolute digestible quantity of each constituent of the rice and the absolute output of each in the fæces were as shown in the following table.

		Riz mi-glacé cuit Boiled half-polished rice	Riz non glacé cuit Boiled unpolished rice
Quantité fournie par 100 gr. de riz non glacé . . . Amount obtained from 100 gms. of unpolished rice		242.76	267.06
Azote total Total nitrogen	Pourcentage — Percentage . . .	0.4864	0.4979
	Quantité — Amount	1.1808	1.3297
	Pourcentage de digestibilité . . . % of digestibility	82.896	75.620
	Quantité totale utilisée . . . . . Total amount utilised	0.9788	1.0055
	Total trouvé dans les selles . . . . Total in the fæces	0.2020	0.3242
Hydrates de carbone Carbohydrate	*Idem*	25.47 61.83 99.216 61.35 0.48	22.61 60.38 98.598 59.53 0.85
Graisse brute Crude fat	*Idem*	0.44 1.07 71.298 0.76 0.31	0.74 1.98 57.144 1.13 0.85
Cendres brutes Crude ash	*Idem*	0.19 0.46 84.600 0.39 0.07	0.27 0.72 78.040 0.56 0.16

Average Mean (%) of the Digestibility of Rice (each Constituent) in Different Grades of Polishing.

Période (degré de glaçage) Period (grades of polishing)	Azote total Total N.	Hydrates de carbone (comme le glycose) Carbohydrate (as glucose)	Graisse brute Crude fat	Cendres brutes Crude ash
Riz glacé. . . . . Polished rice	85.789	99.682	86.816	90.881
Riz glacé à 70% . . . 70% polished rice . .	82.996	99,591	80.510	87.305
Riz mi-glacé . . . . . Half-polished rice . .	81.983	99.296	74.357	84.365
Riz non glacé . . . . Unpolished rice . . .	74.865	98.611	58.272	77.985

Comparison of the Utilised Calories in Each Experiment (Percentage of Total Utilised Calories against Total Calories Intake).

	1re exp. 1st exp.	2me exp. 2nd exp.	3me exp. 3rd exp.	4me exp. 4th exp.	5me exp. 5th exp.	6me exp. 6th exp.
Riz glacé. . . . . Polished rice . . .	97.026	97.376	96.748			
Riz glacé à 70% . . 70% polished rice .	95.776			95.988	95.774	
Riz mi-glacé . . . . Half-polished rice . .		94.852		94.272		94.216
Riz non glacé . . . . Unpolished rice . .			89.468		89.200	90.104

Conclusion.

1. The digestibility and utilisation of rice are always better when the grades of polishing are raised.

The ratio of the actual energy derived from the rice to the total energy value of the rice eaten varied in the same direction as the digestibility.

2. The quantity of rice eaten to supplement standard side dishes was always greater when the polishing grade of rice was higher; when unpolished rice was eaten, the consumption of side dishes was obviously small and it appeared that the caloric intake was insufficient for the requirements of the body.

3. The excretion rate of total nitrogen (*i.e.* the ratio of total nitrogen in the urine to total ingested nitrogen) was higher when the rice was more highly polished; it seemed on the other hand that the excretion rate of urea (the ratio of urea to total nitrogen in the urine) was generally lower under similar circumstances. With regard to the distribution of other nitrogenous substances in the urine, we did not find any significant differences.

4. The quantity of total sulphur in the urine was always proportional to the total nitrogen.

5. The output of phosphate in the urine generally decreased as the grade of polishing of the ingested rice was raised; no such difference was found in the output of chloride.

6. The output of fæces decreased as the grade of polishing of the rice was raised.

7. The quantity of nitrogenous substances in half-polished rice is very nearly the same as in unpolished rice.

8. Under the same conditions, the absolute quantity of each ingredient of rice in the fæces was always smaller when the rice was polished to a higher degree.

8.

THE DIGESTIBILITY AND UTILISATION OF RICE COOKED BY DIFFERENT METHODS.

By K. Sugimoto, M. Higuchi, S. Momoyeda, S. Tanaka and Y. Yasuda.

(From the Imperial State Institute for Nutrition, Tokyo.)

The abstracts of these experiments were published at the tenth, eleventh and twelfth meetings of the Imperial State Institute for Nutrition in Tokyo, and at the third meeting of the Physiological Society of Japan.

In Japan, rice is used in many forms besides that of ordinary boiled rice. There have been no previous references to this subject in the literature, so we have investigated it under Dr. Saiki's supervision.

Our experiments were conducted under ordinary conditions of life, and the men of the Institute who acted as subjects resided at the Institute during the period of experiment. The temperature and the body weight of the subjects were recorded each day. Each experiment lasted six days. The first two days were a preparatory period, during which ordinary boiled rice was taken as the main item of food; during the third and fourth days the experimental food was taken; and during the fifth and sixth days and the morning of the seventh day boiled rice was again taken. In Experiment VIII, during the first two days "okowa" was taken; during the third and fourth days "mochi"; and during the fifth and sixth days and the morning of the seventh day "okowa" was again taken.

The rice used was Shonai rice, quality No. 3; it was polished at the Institute by a special polishing machine, without the use of polishing powder. Before each meal, eight "go" (1,122 gms.) of the polished rice were washed until the wash-water was almost clear and then cooked. The amount of water used in cooking the rice was two litres.

The side dishes eaten by each subject were kept constant throughout the experiment, while the main food and drinking-water were taken *ad libitum*. The quantities of the two latter were recorded.

The daily side dishes were as follows:

Meal	Side dishes	Materials	Quantities
Morning meal	Miso soup	Miso	38 gms.
		Wakame (wet)	20 »
		Dried fish powder	3 »
		Water	300 cc.
	Takuwan		30 gms.
Noon meal	Nitsuke (stew)	Pork	50 gms.
		Potato	100 »
		Tofu (toasted)	50 »
		Burdock	30 »
		Sugar	2 »
		Shoyu	30 cc.
		Water	300 »
	Daikon (grated)	Daikon	30 gms.
		Shoyu	5 cc.
Evening meal	Soup	Tofu	100 gms.
		Dried fish powder	3 »
		Shoyu	25 cc.
		Water	300 »
	Nuta (fish salad)	Mackerel	40 gms.
		Cabbage	25 »
		Onion	15 »
		Miso	20 »
		Vinegar	20 cc.
		Sugar	15 gms.
	Takuwan		30 gms.

The daily quantity of each constituent of the ration (total nitrogen, carbohydrate as glucose, crude fat and crude ash) and the output of fæces were estimated daily by the methods reported in the previous experiment on "The Digestibility and Utilisation of Rice in Different Grades of Polishing". The daily output of urine was analysed to determine the nitrogen balance and the variations in the nitrogenous compounds, P_2O_5, SO_3 and NaCl in the urine. The caloric value of the food actually utilised was also calculated.

Experiment I.

Comparison of the Digestibility and Utilisation of "Dango" (made of Polished Rice) and Ordinary Boiled Rice.

For the preparation of "Dango", 650 cc. of water were added to 1,200 gms. of powdered rice. The mixture was then formed into balls of 50 to 60 gms. in weight and cooked by the subjects themselves in 400 cc. of water. To prevent any loss of food, the water in which the "dango" had been cooked was used in making the soup for the evening meal.

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
		Fev. - Feb.	(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Sugimoto	Riz cuit Boiled rice	1	10.8707	9.3384	86.20	0.8154	7.50	0.2338	2.15	0.0206	0.19	0.1463	1.34	0.4895	4.50	0.0081	0.07
		2	10.5616	8.8571	82.91	0.6387	6.05	0.2358	2.23	0.0167	0.16	0.1634	1.55	0.5376	5.00	0.0148	0.14
		Moy-Aver	10.7162	9.0978	84.56	0.7771	6.78	0.2348	2.19	0.0187	0.18	0.1549	1.45	0.5131	4.30	0.0115	0.11
	Dango	3	11.1798	9.3751	84.86	0.4676	4.18	0.2308	2.06	0.0219	0.20	0.1766	1.58	0.5103	4.56	0.0088	0.08
		4	11.0768	9.3417	84.28	0.6045	5.46	0.2010	1.81	0.0206	0.18	0.1542	1.39	0.5236	4.73	0.0140	0.13
		Moy-Aver	11.1283	9.3584	84.07	0.5361	4.82	0.2159	1.99	0.0213	0.19	0.1654	1.40	0.5169	4.65	0.0114	0.11
	Riz cuit Boiled rice	5	11.0253	9.1771	83.24	0.5930	5.38	0.1961	1.78	0.0205	0.19	0.1348	1.22	0.5018	4.55	0.0172	0.16
		6	10.3040	8.6260	83.71	0.6159	5.98	0.2159	2.10	0.0213	0.21	0.1548	1.50	0.5018	4.87	0.0218	0.21
		Moy-Aver	10.6647	8.9016	83.48	0.6045	5.68	0.2060	1.94	0.0209	0.20	0.1448	1.36	0.5018	4.71	0.0195	0.19
Higuchi	Riz cuit Boiled rice	1	9.7373	7.3938	77.99	0.5930	6.09	0.2015	2.07	0.0235	0.24	0.1510	1.55	0.4652	4.78	0.0109	0.11
		2	11.0253	9.1581	83.06	0.7071	6.41	0.2234	2.00	0.0155	0.14	0.1595	1.45	0.4741	4.30	0.0114	0.10
		Moy-Aver	10.8313	7.5960	80.53	0.6501	6.25	0.2125	2.04	0.0195	0.19	0.1553	1.50	0.4697	4.54	0.0112	0.11
	Dango	3	11.1243	9.2339	83.01	0.5132	4.61	0.1936	1.74	0.0193	0.17	0.1980	1.74	0.4652	4.18	0.0109	0.09
		4	11.1798	9.2733	82.94	0.6957	6.22	0.2134	1.91	0.0200	0.18	0.1970	1.76	0.4652	4.16	0.0147	0.13
		Moy Aver	11.1521	9.2536	82.98	0.6045	5.42	0.2035	1.83	0.0197	0.18	0.1975	1.75	0.4652	4.17	0.0128	0.11
	Riz cuit Boiled rice	5	11.3344	8.9004	78.52	0.6729	5.93	0.1986	1.75	0.0219	0 19	0.1402	1.23	0.4817	4.25	0.0117	0.10
		6	10.7677	9.2610	86.00	0.6558	6.09	0.1986	1.84	0.0206	0 19	0.1595	1.48	0.4652	4.32	0.0147	0.14
		Moy-Aver	11.0511	9.0807	82.26	0.6644	6.01	0.1986	1.80	0.0213	0.19	0.1499	1.36	0.4735	4.29	0.0132	0.12
Momoyeda	Riz cuit Boiled rice	1	9.8403	7.9528	80.62	0.6843	6.95	0.2278	2.31	0.0193	0.19	0.1463	1.48	0.5190	5.27	0 0135	0.13
		2	10.8192	9.3633	86.54	0.6729	6.22	0.2234	2.06	0.0155	0.14	0.1782	1.50	0.5790	5.25	0.0114	0.11
		Moy-Aver	10.3298	8.6581	83.68	0.6786	6.59	0.2256	2.19	0.0174	0.17	0.1623	1.49	0.5490	5.26	0.0125	0.12
	Dango	3	11.5920	9.3499	85.66	0.5246	4.52	0.2506	2.16	0.0206	0.18	0.1935	1.67	0.5427	4.68	0.0201	0.17
		4	11.9526	9.6142	80.43	0.6501	5.45	0.2035	1.70	0 0232	0.12	0.2150	1.79	0.5190	4.34	0.0196	0.17
		Moy-Aver	11.7723	9.4821	83.05	0.5874	4.99	0.2271	1.93	0.0219	0.15	0.2043	1.73	0.5309	4.51	0.0199	0.17

(Continuation.)

Sujets Subjects	Période Period	Date Fev.-Feb.	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	Azote de l'urée Urea N. (%)	Azote de NH^3 Ammonia N. (g)	Azote de NH^3 Ammonia N. (%)	Azote de l'acide urique Uric acid N. (g)	Azote de l'acide urique Uric acid N. (%)	Azote des bases puriques Purin base N. (g)	Azote des bases puriques Purin base N. (%)	Azote des acides aminés Amino acid N. (g)	Azote des acides aminés Amino acid N. (%)	Azote de la créatinine Creatinin N. (g)	Azote de la créatinine Creatinin N. (%)	Azote de la créatine Creatin N. (g)	Azote de la créatine Creatin N. (%)
Momoye-da	Riz cuit Boiled rice	5	11.5920	8.8082	80.98	0.6671	5.75	0.1812	1.56	0.0235	0.20	0.1683	1.59	0.5236	4.51	0.0140	0.12
		6	12.3648	9.3247	80.41	0.7025	5.68	0.2060	1.66	0.0219	0.18	0.1634	1.32	0.5190	4.19	0.0196	0.16
		Moy-Aver	11.9784	9.0665	80.70	0.6848	5.72	0.1946	1.61	0.0227	0 19	0.1659	1.46	0.5213	4.35	0.0168	0.14
Tanaka	Riz cuit Boiled rice	1	9.8403	8.2292	83.63	0.4675	4.75	0.1940	1.97	0.0258	0.26	0 1510	1.53	0.4817	4.89	0.0201	0.20
		2	10.5616	8.8195	83.50	0.5018	4.75	0.2333	2.21	0.0193	0.18	0.1689	1.59	0.4856	4.59	0.0162	0.15
		Moy-Aver	10.2010	8.3848	83.57	0.4847	4.75	0 2137	2.09	0.0226	0.22	0.1600	1.56	0.4837	4.74	0.0182	0.18
	Dango	3	11.4889	9.0448	78.73	0.4220	3.67	0.2035	1.77	0.0235	0.20	0.2076	1.81	0.4895	4.26	0.0340	0.29
		4	10 5101	8.5905	81.73	0.5702	5.52	0.1936	1.84	0.0174	0.16	0.1963	1.87	0.4779	4.54	0.0324	0.30
		Moy-Aver	10.9995	8.8177	80.23	0.4961	4.60	0.1986	1.81	0.0205	0.18	0.2020	1.84	0.4837	4.40	0.0332	0.30
	Riz cuit Boiled rice	5	10.3859	8.3939	80.82	0.5018	4.83	0.2060	1.98	0.0251	0.24	0.1683	1.62	0.4856	4.67	0.0204	0.19
		6	10.4374	8.6165	82.55	0.5246	5.02	0.2308	2 21	0.0232	0.22	0.1634	1.56	0.4817	4.61	0.0372	0.35
		Moy-Aver	10.4117	8.5052	81.69	0.5132	4.93	0.2184	2.10	0.0242	0.23	0.1659	1.59	0.4837	4.64	0.0288	0.27
Yasuda	Riz cuit Boiled rice	1	9.9434	8.5271	85.75	0.5246	5.26	0.2134	2.14	0.0290	0.29	0.1416	1.42	0.5376	5.40	0.0098	0.10
		2	11.2481	9.1265	81.13	0.5319	4.73	0.2573	2.29	0.0219	0.19	0.1779	1.58	0.5510	4.90	0.0102	0.09
		Moy-Aver	10.5958	8.8268	83.44	0.5283	5.00	0.2354	2.22	0.0255	0.24	0.1598	1.50	0.5443	5.15	0.0100	0.10
	Dango	3	11.2314	8.7187	77.63	0.4448	3.96	0.2506	2.23	0.0206	0.17	0.1793	1.59	0.5427	4.83	0.0149	0.13
		4	11.1798	8.8618	79.26	0.5816	5.19	0.2085	1.86	0.0213	0.19	0.1823	1.63	0.5282	4.71	0.0192	0.17
		Moy-Aver	11.2056	8.7903	78.45	0.5132	4.58	0.2296	2.05	0.0210	0.18	0.1808	1.61	0.5360	4.77	0.0171	0.15
	Riz cuit Boiled rice	5	11.4374	8.9332	78.11	0.6501	5.68	0.2234	1.95	0.0232	0.20	0.1636	1.43	0.5376	4.70	0.0098	0.08
		6	11.5044	9.7249	84.53	0.5518	4.79	0.2134	1.85	0.0122	0.19	0.1961	1.70	0.5299	4.60	0.0128	0.11
		Moy-Aver	11.4709	9.3291	81.32	0.6010	5.24	0.2184	1.90	0.0222	0.20	0.1799	1.57	0.5338	4.65	0.0113	0.10

Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Sugimoto			Higuchi		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
	Fév.-Feb.						
Riz cuit	1	1.8462	1.6992	20.7	1.8112	1.6638	14.7
	2	1.7323	1.9824	18.5	1.8750	2.0621	19.4
Boiled rice	Moyenne — Aver.	1.7893	1.8408	19.6	1.8431	1.8630	17.1
	3	1.9039	1.9205	18.4	1.9710	1.8939	19.7
Dango	4	108.57	1.9116	17.4	1.7989	1.9293	17.5
	Moyenne — Aver.	1.8548	1.9111	17.9	1.8850	1.9116	18.6
	5	1.7054	1.8562	16.7	1.6561	2.0178	17.7
Riz cuit	6	1.8256	1.7523	15.0	1.8558	1.9647	20.3
Boiled rice	Moyenne — Aver.	1.7655	1.8043	15.9	1.7560	1.9913	19.0

Période Period	Date	Momoyeda			Tanaka			Yasuda		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
	Fév.-Feb.									
Riz cuit	1	1.7845	1.6815	17.7	1.7769	1.4691	19.3	1.8770	1.8231	19.5
	2	1.9935	2.1152	17.6	1.7529	1.9028	18.2	2.1334	1.9028	20.5
Boiled rice	Moyenne — Aver.	1.8890	1.8984	17.7	1.7649	1.6860	18.8	2.0052	1.8630	20.0
	3	2.0224	1.9293	18.0	2.0699	2.0532	20.0	2.0024	2.0532	15.1
Dango	4	1.9792	1.8939	17.7	1.6316	1.7169	15.9	1.9012	2.0629	15.5
	Moyenne — Aver.	2.0008	1.9111	17.9	1.8508	1.8851	18.0	1.9518	2.0581	15.3
	5	2.0227	2.0444	16.6	1.7351	1.8496	19.5	1.8908	2.1594	16.1
Riz cuit	6	1.9785	1.9559	19.4	1.9785	1.9293	18.7	1.9516	1.7700	19.0
Boiled rice	Moyenne — Aver.	2.0006	2.0002	18.0	1.8568	1.8895	19.1	1.9212	1.9647	17.6

Sujets / Subject	Période / Period	Absorption d'azote Moyenne journalière — N. intake Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Azote trouvé dans l'urine Moyenne journalière — N. in urine Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Azote trouvé dans les selles Moyenne journalière — N. in fæces Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière — Absorption Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	Pourcentage d'absorption % of absorption
Sugimoto .	Riz cuit . . . . Boiled rice . . .	12.9552	80.9700	10.7162	82.72	2.2266	17.19	+ 0.0124	10.7286	67.0538	274.921	82.81
	Dango	13.9711	81.6944	11.1283	85.13	2.0962	16.03	— 0.1534	10.9749	68.5931	281.232	83.97
	Riz cuit . . . . Boiled rice . . .	12.9552	80.9700	10.6647	82.32	2.4053	18.56	— 0.1148	10.5499	65.9369	270.341	81.44
Higuchi .	*Idem*	12.9552	80.9700	10.3813	80.13	2.4717	19.08	+ 0.1022	10.4835	65.5219	268.640	80.92
		13.9133	86.9581	11.1521	80.16	2.3479	16.87	+ 0.4133	11.5654	72.2838	296.364	83.13
		13.1467	82.1669	11.0511	84.06	2.7485	20.90	— 0.6529	10.3982	64.9888	266.454	79.09
Momoyeda	*Idem*	13.7210	85.7562	10.3298	75.29	2.0569	15.00	+ 1.3343	11.6641	72.9006	298.892	85.00
		12.7571	79.7319	11.7723	92.29	1.2594	9.87	— 0.2746	11.4977	71.8606	294.628	90.13
		13.9125	86.9531	11.9784	86.10	2.3044	16.56	— 0.3703	11.6081	72.5506	297.457	83.44
Tanaka . .	*Idem*	13.3381	83.3631	10.2010	76.48	2.5675	19.24	+ 0.5696	10.7706	67.3163	275.997	80.76
		13.9133	86.9581	10.9995	79.06	1.9664	14.12	+ 0.9474	11.9469	74.6681	306.139	85.88
		13.3381	83.3631	10.4117	78.04	2.2436	16.82	+ 0.6828	11.0945	69.3506	284.337	83.18
Yasuda . .	*Idem*	12.9552	80.9700	10.5958	81.79	2.4824	19.16	— 0.1230	10.4728	65.4550	268.366	80.84
		12.7571	79.7319	11.2056	95.67	2.2454	17.60	— 0.6939	10.5117	65.6981	269.362	82.40
		14.1039	88.1494	11.4709	81.33	2.9417	20.07	— 0.3087	11.1622	69.7638	286.032	79.93

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Sugimoto	Riz cuit . . . Boiled rice . .	415.91	1.6990	0.41	414.21	1698.261	99.59
	Dango . . .	425.00	1.1896	0.28	423.81	1737.621	99.72
	Riz cuit . . . Boiled rice . .	415.91	1.9634	0.74	413.95	1697.195	99.53
Higuchi .	*Idem*	415.91	1.5404	0.37	414.37	1698.917	99.63
		499.01	1.5357	0.30	497.47	2039.627	99.70
		430.95	2.3568	0.54	428.59	1757.219	99.46
Momoyeda	*Idem*	476.07	1.9274	0.41	474.14	1943.974	99.59
		400.33	1.2047	0.30	399.13	1636.433	99.70
		491.11	2.3599	0.48	488.75	2003.875	99.52
Tanaka .	*Idem*	445.99	1.6048	0.36	444.39	1821.999	99.64
		499.01	1.1085	0.22	497.90	2041.390	99.78
		445.99	1.5858	0.35	444.40	1822.040	99.65
Yasuda .	*Idem*	415.91	2.0724	0.49	413.84	1696.744	99.51
		400.33	2.1808	0.54	398.15	1632.415	99.46
		506.15	3.3061	0.65	502.84	2061.644	99.35

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Sugimoto	Riz cuit . . . Boiled rice . .	19.38	2.6264	13.55	16.75	155.775	86.45
	Dango . . .	19.46	1.7973	9.23	17.66	163.238	90.77
	Riz cuit . . . Boiled rice . .	19.38	2.2111	11.41	17.17	159.681	88.59
Higuchi .	*Idem*	19.38	2.1714	11.20	17.21	60.056	88.80
		20.07	2.1532	10.73	17.92	66.656	89.27
		19.51	3.0898	15.83	16.42	152.706	84.17
Momoyeda	*Idem*	9.86	2.5394	12.77	17.34	161.262	87.23
		19.25	1.4090	7.32	17.84	165.912	92.68
		20.01	3.7155	18.57	16.29	151.497	81.43
Tanaka .	*Idem*	19.63	2.8753	14.65	16.76	155.868	85.35
		20.07	1.5152	7.55	18.56	172.608	92.45
		9.63	2.0371	10.38	17.59	163.587	89.62
Yasuda .	*Idem*	19.38	2.7898	14.39	16.59	154.287	85.61
		19.25	2.0143	10.62	17.21	160.053	89.38
		20.13	3.8933	14.37	16.24	151.032	85.63

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Sugimoto .	Riz cuit	24.11	3.5720	14.82	85.18
	Boiled rice				
	Dango	24.44	2.8781	11.92	88.08
	Riz cuit	24.11	3.7289	15.47	81.53
	Boiled rice				
Higuchi .	*Idem*	24.11	3.4334	14.24	85.76
		24.41	2.9393	12.04	87.96
		24.17	3.9907	16.51	83.49
Momoyeda	*Idem*	24.33	3.3371	13.31	86.69
		24.05	2.2300	9.27	90.73
		24.49	3.7037	15.18	84.82
Tanaka .	*Idem*	24.22	3.7689	15.56	84.44
		24.41	3.0318	12.42	87.58
		24.22	3.4868	14.39	85.61
Yasuda .	*Idem*	24.11	3.9732	16.48	83.52
		24.05	3.1001	14.13	85.87
		24.44	4.1702	17.06	82.94

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Caloric utilisation		% de la quantité de calories absorbée % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Sugimoto .	Riz cuit . . . . Boiled rice . . .	2217.442	36.44	2128.957	34.98	95.99
	Dango	2258.425	37.39	2182.091	36.12	96.60
	Riz cuit . . . . Boiled rice . . .	2217.442	36.84	2127.217	35.34	95.98
Higuchi .	*Idem*	2217.442	42.52	2127.613	40.80	95.95
		2589.110	49.80	2502.647	48.13	96.65
		2285.222	44.11	2176.379	42.01	95.34
Momoyeda	*Idem*	2488.377	42.64	2404.128	41.20	96.62
		2147.276	37.11	2096.973	36.25	97.68
		2556.151	44.20	2452.829	42.41	95.95
Tanaka .	*Idem*	2352.906	44.65	2253.864	42.77	95.81
		2589.110	49.05	2520.137	47.75	97.35
		2352.906	44.56	2269.964	42.99	96.47
Yasuda .	*Idem*	2217.442	34.30	2119.397	32.78	95.56
		2147.279	33.53	2061.830	32.20	96.03
		2623.836	41.00	2408.708	39.04	95.22

Percentage of Digestibility and Utilisation of Each Constituent.

Période Period	Azote total Total nitrogen %	Hydrates de carbone (comme le glycose) Carbo-hydrate as glucose %	Graisse brute Crude fat %	Cendres brutes Crude ash %	Calories %
Riz cuit — Boiled rice	82.066	99.592	86.688	85.188	95.986
Dango	85.102	99.672	90.910	88.044	96.862
Riz cuit — Boiled rice	81.416	99.502	85.888	84.278	95.762

Conclusion.

1. The digestibility and utilisation of rice were better when "dango" was used than when ordinary boiled rice was used. The same quantity of energy was supplied in each case.

2. The output of total nitrogen in the urine was greater when "dango" was used than when boiled rice was used, but the ratio of individual nitrogenous compounds to the total nitrogen in the urine was almost constant during each period.

3. The daily output of fæces (wet and dry) was smaller when "dango" was used; the quantities of boiled rice and of "dango" eaten were nearly the same.

Experiment II.

Comparison of the Digestibility and Utilisation of Boiled Polished Rice, "Dango" (made of Unpolished Rice), and Boiled Unpolished Rice.

The method of preparation of "dango" was the same as before, but in this experiment we used the powder of unpolished rice instead of using polished-rice flour.

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date Mars-March	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
			(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Yamamoto	Riz glacé cuit	7	9.3766	7.9518	84.81	0.4562	4.87	0.1940	2.07	0.0200	0.21	0.1516	1.62	0.4652	4.96	0.0109	0.12
	Boiled polished	8	9.2736	7.7535	83.61	0.5474	5.90	0.2114	2.28	0.0219	0.24	0.1690	1.82	0.4704	5.07	0.0113	0.12
	rice	Moy-Aver	9.3251	7.8527	84.21	0.5018	5.38	0.2027	2.18	0.0210	0.23	0.1603	1.72	0.4678	5.02	0.0111	0.12
	Dango (non	9	10.0979	8.7310	86.47	0.4903	4.86	0.2189	2.17	0.0174	0.17	0.1799	1.78	0.4741	4.70	0.0276	0.27
	glacé)	10	10.5060	7.8908	75.11	0.6159	5.86	0.1642	1.56	0.0180	0.17	0.1700	1.62	0.4596	4.38	0.0220	0.21
	Dango (unpol.)	Moy-Aver	10.3020	8.3109	80.79	0.5531	5.36	0.1916	1.87	0.0177	0.17	0.1750	1.70	0.4669	4.54	0.0248	0.24
	Riz n. glacé cuit	11	10.3040	8.6300	83.61	0.7299	7.08	0.1940	1.88	0.0206	0.20	0.1719	1.67	0.4596	4.46	0.0337	0.33
	Boiled unpol.	12	9.2736	7.3711	79.48	0.7527	8.12	0.2065	2.23	0.0264	0.28	0.1610	1.74	0.4527	4.88	0.0177	0.36
	rice	Moy-Aver	9.7888	8.0006	81.55	0.7413	7.60	0.2003	2.06	0.0235	0.24	0.1665	1.71	0.4562	4.67	0.0257	0.35
Momoyeda	Boiled polished	7	11.4374	9.1270	79.81	0.9124	7.98	0.1890	1.65	0.0270	0.24	0.1516	1.33	0.5846	5.11	0.0116	0.10
	rice	8	10.0979	8.1986	81.19	0.7071	7.00	0.1940	1.92	0.0232	0.23	0.1784	1.77	0.5903	5.86	0.0178	0.18
	Riz glacé cuit	Moy-Aver	10.7677	8.6628	80.50	0.8098	7.49	0.1915	1.79	0.0251	0.24	0.1650	1.55	0.5875	5.49	0.0147	0.14
	Dango (non	9	11.0252	8.2000	74.38	0.6957	6.31	0.1990	1.80	0.0290	0.26	0.1847	1.68	0.5789	5.26	0.0113	0.12
	glacé)	10	13.2921	10.5899	79.67	0.7755	5.84	0.1865	1.40	0.0245	0.18	0.1795	1.35	0.5575	4.19	0.0159	0.12
	Dango (unpol.)	Moy-Aver	12.1587	9.3950	77.03	0.7356	6.08	0.1928	1.60	0.0268	0.22	0.1821	1.52	0.5682	4.73	0.0136	0.12
	Riz n. glacé cuit	11	11.0768	9.1822	82.90	0.7641	6.90	0.2138	1.93	0.0238	0.21	0.1673	1.51	0.5734	5.18	0.0168	0.15
	Boiled unpol.	12	9.9425	7.6790	77.23	0.8440	8.49	0.2065	2.08	0.0303	0.30	0.1704	1.71	0.5484	5.52	0.0101	0.10
	rice	Moy-Aver	10.5097	8.4306	80.07	0.8041	7.70	0.2102	2.01	0.0271	0.26	0.1689	1.61	0.5609	5.35	0.0135	0.13
Tanaka	Riz glacé cuit	7	10.5616	8.1384	77.06	0.6159	5.83	0.2164	2.05	0.0245	0.23	0.1659	1.57	0.4856	4.60	0.0379	0.36
	Boiled polished	8	11.1283	9.4126	84.58	0.5930	5.33	0.1816	1.63	0.0290	0.26	0.1643	1.48	0.5018	4.51	0.0409	0.37
	rice	Moy-Aver	10.8450	8.1930	80.82	0.6045	5.58	0.1990	1.84	0.0268	0.25	0.1651	1.53	0.4937	4.56	0.0394	0.37
	Dango (non	9	11.6435	9.5479	82.00	0.6501	5.58	0.1990	1.71	0.0187	0.16	0.1604	1.39	0.5103	4.38	0.0472	0.41
	glacé)	10	12.7769	9.7286	76.14	0.6159	4.82	0.2189	1.71	0.0232	0.18	0.1747	1.37	0.5018	3.93	0.0716	0.56
	Dango (unpol.)	Moy-Aver	12.2102	9.6383	79.07	0.6330	5.20	0.2090	1.71	0.0210	0.17	0.1676	1.38	0.5061	4.16	0.0594	0.49

(Continuation).

Sujets Subjects	Période Period	Date Mars-March	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
			(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Tanaka	Riz n. glacé cuit	11	10.1072	8.2001	81.14	0.5816	5.75	0.1915	1.89	0.0290	0.29	0.1766	1.75	0.5103	5.05	0.0687	0.68
	Boiled unpol.	12	11.6950	10.0196	85.67	0.6159	5.27	0.2338	2.00	0.0270	0.23	0.1704	1.46	0.5191	4.44	0.0544	0.47
	rice	Moy-Aver	10.9011	9.1099	83.41	0.5988	5.51	0.2127	1.95	0.0280	0.26	0.1735	1.61	0.5147	4.75	0.0626	0.58
Ishibashi	Riz glacé cuit	7	10.5101	8.6676	82.46	0.6843	6.51	0.2040	1.94	0.0258	0.25	0.1611	1.53	0.4817	4.58	0.0508	0.48
	Boiled polished	8	10.0464	8.3949	83.56	0.6501	6.47	0.1567	1.56	0.0245	0.24	0.1878	1.87	0.4460	4.44	0.0172	0.17
	rice	Moy-Aver	10.2283	8.5293	83.01	0.6672	6.49	0.1804	1.75	0.0252	0.25	1.1745	1.70	0.4639	4.51	0.0340	0.33
	Dango (non	9	11.8800	9.8005	82.49	0.8440	7.10	0.2338	1.97	0.0219	0.18	0.1799	1.51	0.4704	3.96	0.0442	0.37
	glacé)	10	11.7264	8.7018	74.21	0.8782	7.49	0.2088	1.78	0.0206	0.17	0.1795	1.53	0.4652	3.96	0.0302	0.25
	Dango (unpol.)	Moy-Aver	11.8032	9.2512	78.35	0.8611	7.30	0.2213	1.88	0.0213	0.18	0.1797	1.52	0.4678	3.96	0.0372	0.31
	Riz n. glacé cuit	11	11.3648	9.1353	80.38	0.7299	6.42	0.1989	1.75	0.0251	0.22	0.1859	1.63	0.4934	4.34	0.0348	0.31
	Boiled unpol.	12	10.0252	8.2126	81.92	0.9352	9.33	0.2089	2.08	0.0270	0.27	0.1610	1.61	0.4976	4.96	0.0497	0.49
	rice	Moy-Aver	10.6950	8.6740	81.15	0.8326	7.38	0.2039	1.92	0.0261	0.25	0.1735	1.62	0.4955	4.65	0.0423	0.40
Kayano	Riz glacé cuit	7	9.8918	7.6816	77.65	0.6273	6.34	0.2139	2.16	0.0251	0.25	0.1564	1.59	0.4301	4.35	0.0094	0.09
	Boiled polished	8	9.6342	7.7844	80.79	0.5930	6.15	0.1443	1.49	0.0232	0.24	0.1549	1.61	0.4395	4.56	0.0099	0.13
	rice	Moy-Aver	9.7630	7.7330	79.22	0.6102	6.25	0.1791	1.83	0.0242	0.25	0.1557	1.60	0.4348	4.46	0.0097	0.11
	Dango (non	9	10.0768	7.8735	78.13	0.4903	4.96	0.2462	2.44	0.0238	0.23	0.1657	1.64	0.4527	4.49	0.0141	0.14
	glacé)	10	12.5708	9.3543	74.41	0.6045	4.81	0.1940	1.54	0.0245	0.19	0.1747	1.39	0.4527	3.60	0.0069	0.05
	Dango (unpol.)	Moy-Aver	11.3238	8.6138	76.27	0.5974	4.89	0.2201	1.99	0.0242	0.21	0.1702	1.52	0.4527	4.05	0.0105	0.10
	Riz n. glacé cuit	11	10.5101	8.9641	85.29	0.6159	5.86	0.1866	1.77	0.0245	0.23	0.1766	1.68	0.4596	4.37	0.0107	0.10
	Boiled unpol.	12	10.0979	8.0688	79.90	0.6957	6.88	0.2065	2.04	0.0232	0.23	0.1562	1.54	0.4527	4.48	0.0105	0.10
	rice	Moy-Aver	10.3040	8.5165	82.60	0.6558	6.37	0.1966	1.91	0.0239	0.23	0.1664	1.61	0.4562	4.43	0.0106	0.10

Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Yamamoto			Momoyeda		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz glacé cuit	Mars-Mar. 7	1.6650	1.2390	17.5	1.9488	1.5045	21.6
Boiled polished rice	8	1.6252	1.9824	18.5	1.5850	1.3279	19.2
	Moyenne —Aver.	1.6452	1.6107	18.0	1.7669	1.4162	20.4
Dango non glacé	9	1.6148	1.8054	17.4	1.8268	1.8585	16.2
Dango unpolished	10	1.8505	1.8408	17.9	2.1418	2.2302	19.1
	Moyenne —Aver.	1.7327	1.8231	17.7	1.9843	2.0444	17.7
Riz non glacé cuit	11	1.9580	1.9647	19.4	1.8838	1.8408	17.8
Boiled unpol. rice	12	1.4524	2.0355	19.3	1.9332	2.1063	15.3
	Moyenne —Aver.	1.7052	2.0001	19.4	1.9085	1.9736	16.6

Période Period	Date	Tanaka			Ishibashi			Kayano		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz glacé cuit	Mars-Mar. 7	1.9366	1.5399	20.2	1.8310	1.2052	19.3	1.6938	1.0620	22.0
Boiled polished rice	8	1.8832	1.6993	18.2	1.7338	1.6461	15.2	1.6868	1.4868	16.6
	Moyenne —Aver.	1.9099	1.6196	19.2	1.7824	1.4257	17.3	1.6903	1.2744	19.3
Dango non glacé	9	2.1348	2.0709	17.7	2.0890	1.9116	18.1	1.7288	2.1594	16.6
Dango unpolished	10	2.0882	2.1063	17.3	2.0080	2.2656	16.8	2.2324	1.9293	18.0
	Moyenne —Aver.	2.1115	2.0886	17.5	2.0485	2.0886	17.5	1.9806	2.0444	17.3
Riz non glacé cuit	11	2.0088	1.9470	19.8	2.0328	1.8939	21.4	1.7004	1.7877	16.6
Boiled unpol. rice	12	2.0286	1.9647	21.2	1.6146	2.0001	18.2	1.7200	1.9824	17.8
	Moyenne —Aver.	2.0187	1.9559	20.5	1.8237	1.9420	19.8	1.7102	1.8851	17.2

Sujets / Subject	Période / Period	Absorption d'azote Moyenne journalière — N. intake Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Azote trouvé dans l'urine Moyenne journalière — N. in urine Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Azote trouvé dans les selles Moyenne journalière — N. in fæces Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière — Absorption Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	Pourcentage d'absorption % of absorption
Yamamoto .	Riz glacé cuit / Boiled pol. rice	12.1894	76.1838	9.3251	76.50	1.9741	16.19	+ 0.8902	10.2153	63.8456	261.767	83.81
	Dango non glacé / Dango unpol.	14.5044	90.6525	10.3020	71.02	2.8680	19.77	+ 1.3344	11.6364	72.7275	298.183	80.23
	Riz non glacé cuit / Boiled unpol. rice	14.1214	88.2588	9.7888	69.32	3.1558	22.34	+ 1.1768	10.9656	68.5350	280.994	77.66
Momoyeda	*Idem*	13.3381	83.3631	10.7677	80.73	1.7247	12.93	+ 0.8457	11.6434	72.5838	297.594	87.07
		15.5284	97.0525	12.1587	78.30	2.3205	14.94	+ 1.0492	13.2079	82.5494	338.453	85.06
		14.1214	88.2588	10.5097	74.42	2.7442	19.44	+ 0.9675	11.3772	71.1075	291.541	80.56
Tanaka . .	*Idem*	13.1467	82.1669	10.8450	82.49	1.9291	14.67	+ 0.3726	11.2176	70.1100	287.451	85.33
		15.0164	93.8525	12.2102	81.31	2.3332	17.95	+ 0.4730	12.6832	79.2900	225.007	84.47
		13.5453	84.6581	10.9011	80.47	2.6522	24.15	— 0.0080	10.8931	68.0819	279.136	80.36
Ishibashi .	*Idem*	12.1894	76.1838	10.2283	83.91	1.5347	12.59	+ 0.4264	10.6547	66.5919	273.027	87.41
		14.5044	90.6525	11.8032	81.37	2.6045	17.95	+ 0.0967	11.8999	74.3744	304.935	82.05
		12.3931	77.4569	10.6950	86.30	2.9933	24.15	— 1.2952	9.3998	58.7488	240.870	75.85
Kayano . .	*Idem*	12.5723	78.5769	9.7630	77.65	1.3447	10.70	+ 1.4646	11.2276	70.1725	287.707	89.30
		14.5044	90.6525	11.3238	78.07	2.4629	16.98	+ 0.7177	12.0415	75.2594	308.563	83.02
		14.1214	88.2588	10.3040	72.96	3.0376	21.51	+ 0.7798	11.0838	69.2738	284.023	78.49

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Yamamoto	Riz glacé cuit Boiled pol. rice	355.75	1.9938	0.56	353.76	1450.416	99.44
	Dango non glacé Dango unpol.	334.25	3.8137	1.14	330.44	1354.804	98.86
	Riz non glacé cuit . . . . Boiled unpol. rice	316.35	4.1783	1.32	312.17	1279.897	98.68
Momoyeda	*Idem*	445.99	1.8963	0.42	444.09	1820.769	99.58
		380.80	3.0753	0.81	377.72	1548.652	99.19
		316.35	3.9105	1.23	312.44	1281.004	98.77
Tanaka .	*Idem*	430.95	1.6259	0.38	429.32	1760.212	99.62
		357.53	3.1296	0.87	354.40	1453.040	99.13
		290.21	3.8819	1.33	286.33	1173.953	98.67
Ishibashi.	*Idem*	355.75	0.9990	0.28	354.75	1454.475	99.72
		334.25	3.4692	1.03	330.78	1356.198	98.97
		237.93	5.3486	2.24	232.58	953.578	97.76
Kayano .	*Idem*	385.83	1.5233	0.40	384.35	1575.835	99.60
		334.25	3.5262	1.04	330.72	1355.952	98.96
		316.35	4.5853	1.45	311.76	1278.216	98.55

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Yamamoto	Riz glacé cuit Boiled pol. rice	18.88	2.4007	12.71	16.48	153.264	87.29
	Dango non glacé Dango unpol.	25.50	2.5993	10.19	22.90	212.970	89.81
	Riznon glacé cuit Boil. unpol. rice	24.98	9.9127	39.69	15.07	140.151	60.31
Momoyeda	*Idem*	19.63	2.2938	11.68	17.34	161.262	88.32
		27.02	2.7859	10.31	24.23	225.339	89.68
		24.98	8.4095	33.66	16.57	154.101	66.34
Tanaka .	*Idem*	19.51	2.3787	12.18	17.12	159.216	87.82
		26.26	2.6790	10.20	23.58	218.299	89.80
		24.12	8.7812	36.40	15.34	142.662	63.60
Ishibashi.	*Idem*	18.88	1.9232	10.19	16.96	157.728	89.81
		25.50	3.2484	12.73	22.25	206.925	87.27
		22.40	8.8900	39.68	13.51	125.643	60.32
Kayano .	*Idem*	19.13	1.8817	9.83	17.25	160.425	90.17
		25.50	3.5383	13.87	21.96	204.228	86.13
		24.98	10.3203	41.31	14.66	136.338	58.69

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Yamamoto	Riz glacé cuit	23.89	2.9280	12.25	87.75
	Boiled polished rice . .				
	Dango non glacé . . .	26.27	6.3575	24.20	75.80
	Dango unpolished . .				
	Riz non glacé cuit . .	25.89	7.1039	27.44	72.56
	Boiled unpolished rice				
Momoyeda	*Idem*	24.22	3.1075	12.83	87.17
		26.85	6.4719	24.10	75.90
		25.89	7.0474	27.22	72.78
Tanaka .	*Idem*	24.17	3.2722	13.53	86.47
		26.54	6.1777	23.28	76.72
		25.58	8.5848	33.55	66.45
Ishibashi .	*Idem*	23.89	2.8271	11.41	88.59
		26.27	6.4465	24.54	75.45
		24.96	7.1252	28.54	71.46
Kayano. .	*Idem*	24.01	2.3850	9.93	90.07
		26.27	6.1104	23.26	76.74
		25.89	6.6249	25.59	74.41

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Calories utilisation		% de la quantité de calories absorbées % against calorics intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Yamamoto	Riz glacé cuit. . Boiled pol. rice .	1946.512	41.68	1865.447	39.94	95.82
	Dango non glacé Dango unpol. . .	1979.250	43.03	1865.957	40.56	94.26
	Riz non glacé cuit Boiled unpol. rice	1893.210	41.33	1701.042	37.14	89.86
Momoyeda	*Idem*	2352.906	40.90	2279.625	39.62	96.87
		2210.481	38.78	2112.444	37.06	95.56
		1893.210	33.31	1726.646	30.38	91.20
Tanaka .	*Idem*	2285.222	43.44	2206.879	41.96	96.59
		2094.886	39.82	1997.346	38.01	95.45
		1761.275	33.74	1595.751	30.56	90.57
Ishibashi .	*Idem*	1946.512	39.22	1885.230	37.98	96.83
		1979.250	39.94	1868.058	37.70	94.39
		1501.997	30.72	1320.091	27.01	87.92
Kayano .	*Idem*	2081.997	43.44	2023.967	42.22	97.19
		1979.250	41.55	1868.743	39.23	94.41
		1893.210	39.67	1698.577	35.61	89.77

Digestibility and Utilisation of Each Constituent.

Période Period	Azote total Total nitrogen %	Hydrates de carbone (comme le glycose) Carbo-hydrate as glucose %	Graisse brute Crude fat %	Cendres brutes Crude ash %	Calories %
Riz glacé cuit	86.584	99.592	88.682	88.010	96.660
Boiled polished rice . .					
Dango non glacé cuit .	82.566	99.022	88.538	76.122	94.814
Dango unpolished . .					
Riz non glacé cuit . .	78.584	98.486	61.852	71.532	89.864
Boiled unpolished rice.					

Conclusion.

1. The digestibility and utilisation of each constituent of the unpolished rice were better when " dango " was used than when boiled unpolished rice was used; boiled polished rice was better in this respect than either of the others. The same quantity of energy was supplied in each case.

2. When similar side dishes were eaten, we found that more " dango " made of unpolished rice was consumed than boiled unpolished rice (if the " dango " and the boiled unpolished rice were both reckoned in terms of uncooked rice). The amount of boiled polished rice consumed was the largest of all.

3. The nitrogenous compounds in the urine showed no appreciable difference in any of the periods except in the case of the urea nitrogen; the ratio of urea nitrogen to total urine nitrogen decreased slightly during the " dango " period.

4. The output of fæces was greatest when boiled unpolished rice was used, was smaller during the " dango " period, and was smallest during the boiled polished-rice period. The output of the various constituents in the fæces remained unchanged.

Experiment III.

Comparison of the Digestibility and Utilisation of Rice Gruel (Stewed Rice or " Kayu ") and Ordinary Boiled Rice.

For the preparation of " stewed rice " 424 gms. of polished rice were washed and cooked in a mixture of 8 gms. of NaCl with 3,000 cc. of water. When the mixture began to boil 2,000 cc. of water were added; we obtained an average of 4,985 gms. of " stewed rice ".

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	Azote de l'urée Urea N. (%)	Azote de NH^3 Ammonia N. (g)	Azote de NH^3 Ammonia N. (%)	Azote de l'acide urique Uric acid N. (g)	Azote de l'acide urique Uric acid N. (%)	Azote des bases puriques Purin base N. (g)	Azote des bases puriques Purin base N. (%)	Azote des acides aminés Amino acid N. (g)	Azote des acides aminés Amino acid N. (%)	Azote de la créatinine Creatinin N. (g)	Azote de la créatinine Creatinin N. (%)	Azote de la créatine Creatin N. (g)	Azote de la créatine Creatin N. (%)
Higuchi	Riz cuit Boiled rice	Avril 26	10.3794	8.7950	84.73	0.8440	8.13	0.1700	1.64	0.0238	0.23	0.1579	1.52	0.5018	4.83	0.0129	0.12
		April 27	10.7596	8.8107	81.89	0.5132	4.77	0.1325	1.22	0.0228	0.21	0.1634	1.52	0.5680	5.28	0.0109	0.10
		Moy-Aver	10.5695	8.8029	83.31	0.6786	6.45	0.1513	1.43	0.0233	0.22	0.1607	1.52	0.5349	5.06	0.0119	0.11
	Gruau de riz Rice gruel	Avril 28	12.6264	10.0244	79.39	0.9083	7.11	0.1836	1.45	0.0235	0.19	0.1607	1.27	0.5720	4.53	0.0155	0.12
		April 29	10.6836	8.9604	83.87	0.9466	8.86	0.1400	1.31	0.0280	0.17	0.1785	1.67	0.5326	4.98	0.0149	0.14
		Moy-Aver	11.6550	9 4924	81.63	0.9275	7.99	0.1618	1.38	0.0258	0.18	0.1696	1.47	0.5523	4.76	0.0152	0.13
	Riz cuit Boiled rice	April 30	11.0638	9.4418	85.34	1.0264	9.27	0.1625	1.47	0.0209	0 19	0.1794	1.62	0.5628	5.08	0.0107	0.09
		Mai-May1	11.4440	9.5384	83.35	1.0150	8.87	0.1950	1.70	0.0228	0.19	0.1840	1.60	0.5735	5.01	0.0112	0.09
		Moy-Aver	11.2539	9.4902	84.35	1.0207	9.07	0.1788	1.59	0.0219	0.19	0.1817	1.61	0.5682	5.05	0.0110	0.09
Momoyeda	Riz cuit Boiled rice	Avril 26	10.7596	8.3637	77.73	0.6385	5.93	0.1450	1.35	0.0228	0.21	0.1634	1 52	0.6022	5.60	0.0123	0.11
		April 27	10.4174	8.2117	78.82	0.6159	5.91	0.1800	1.72	0.0219	0.20	0.1679	1.61	0.5846	5.61	0.0115	0.11
		Moy-Aver	10.5885	8.2877	78.28	0.6272	5.92	0.1625	1.54	0.0224	0.21	0.1657	1.57	0.5934	5.61	0.0119	0.11
	Gruau de riz Rice gruel	Avril 28	10.9497	8.4282	76.97	0.8782	8.02	0.1950	1.78	0.0276	0.26	0.1785	1.62	0.6144	5.61	0.0129	0.11
		April 29	11.0258	9.0139	81.75	0.9580	8.68	0.1650	1.49	0.0304	0.27	0.1994	1.80	0.6207	5.63	0.0131	0.11
		Moy-Aver	10.9878	8.7211	79.36	0.9181	8.35	0.1800	1.64	0.0290	0.27	0.1890	1.71	0.6176	5.62	0.0130	0.11
	Riz cuit Boiled rice	April 30	10.9497	9.0904	83.02	1.0721	9.79	0.1850	1.69	0.0295	0.27	0.1748	1.59	0.6022	5.50	0.0186	0.17
		Mai-May1	10.8737	8.9689	82.48	1.0721	9.86	0.1825	1.67	0.0276	0.26	0.1794	1.65	0.6022	5.54	0.0123	0.11
		Moy-Aver	10.9116	9.0297	82.75	1.0721	9.83	0.1838	1.68	0.0286	0.27	0.1771	1.62	0.6022	5.52	0.0155	0.14
Tanaka	Riz cuit Boiled rice	Avril 26	11.2539	9.6653	85.88	0.5792	5.14	0.1825	1.62	0.0266	0.23	0.2270	2.01	0.5236	4.66	0.0786	0.69
		April 27	11.4060	8.8771	77.82	0.5360	4.70	0.1525	1.34	0.0171	0.15	0.2147	1.88	0.5474	4.79	0.0670	0.58
		Moy-Aver	11.3300	9.2712	81.85	0.5576	4.92	0.1675	1.48	0.0219	0.19	0.2209	1.95	0.5355	4.73	0.0728	0.64
	Gruau de riz Rice gruel	Avril 28	11.4820	8.8332	76.93	0.6957	6.06	0.2150	1.87	0.0228	0.19	0.1830	1.59	0.5576	4.94	0.0966	0.84
		April 29	11.1791	8.8345	79.02	0.6957	6.22	0.1925	1.72	0.0352	0.31	0.1562	1.39	0.5326	4.76	0.0696	0.62
		Moy-Aver	11.3256	8.8339	77.98	0.6957	6.14	0.2038	1.80	0.0290	0.25	0.1696	1.49	0.5451	4.85	0.0834	0.73
	Riz cuit Boiled rice	April 30	10.9877	9.3874	85.43	0.8211	7.47	0.2275	2.07	0.0219	0.20	0.1840	1.67	0.5735	5.22	0.0639	0.58
		Mai-May1	10.7216	8.6107	80.31	0.9580	8.93	0.2075	1.93	0.0285	0.26	0.1886	1.76	0.5576	5.20	0.0569	0.53
		Moy-Aver	10.8547	8.9991	82.87	0.8896	8.20	0.2175	2.00	0.0252	0.23	0.1863	1.72	0.5656	5.21	0.0604	0.56

The Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Higuchi			Momoyeda			Tanaka		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz cuit Boiled rice	Av.-Apr. 26	1.7597	1.9449	21.0	1.9450	1.4678	20.0	2.0582	1.7247	19.3
	27	1.9230	2.0709	16.0	1.8791	1.6513	17.3	2.0843	1.9999	16.0
	Moyenne —Aver.	1.8414	2.0079	18.5	1.9121	1.5596	18.7	2.0713	1.8623	17.7
Gruau de riz Rice gruel	28	2.0768	1.8128	29.0	1.8654	1.7431	20.5	2.0441	1.7431	20.2
	29	2.0910	1.4495	19.7	1.9120	1.5779	21.1	1.9676	1.7431	22.0
	Moyenne —Aver.	2.0839	1.6312	24.4	1.8887	1.6605	20.8	2.0058	1.7431	21.1
Riz cuit Boiled rice	30 Mai-May	1.9477	1.6697	17.8	1.9634	1.9999	17.5	2.0588	1.9082	19.4
	1	1.8956	1.7798	18.4	1.8386	1.8531	19.1	1.9240	1.6697	19.6
	Moyenne —Aver.	1.9217	1.7248	18.1	1.9010	1.9265	18.3	1.9914	1.7890	19.5

Nitrogen Balance: the Digestibility and Utilisation, and Caloric Value.

Sujets / Subject	Période / Period	Absorption d'azote Moyenne journalière — N. intake Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Azote trouvé dans l'urine Moyenne journallère — N. in urine Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Azote trouvé dans les selles Moyenne journalière — N. in fæces Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière — Absorption Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	Pourcentage d'absorption % of absorption
Higuchi . .	Riz cuit . . . . Boiled rice . . .	13.7172	85.7325	10.5695	77.05	1.8217	13.28	+ 1.3260	11.8955	74.3469	304.822	86.72
	Gruau de riz . . Rice gruel . . .	9.6468	60.2925	11.6550	120.81	1.5212	15.77	— 3.5294	8.1256	50.7850	208.219	84.23
	Riz cuit . . . . Boiled rice . . .	14.1636	88.5225	11.2539	79.45	1.8254	12.88	+ 1.0843	12.3382	77.1138	316.167	87.12
Momoyeda	*Idem*	13.9404	87.1275	10.5885	75.95	2.3013	16.65	+ 1.0706	11.6391	72.7444	298.252	83.35
		9.6468	60.2925	10.9878	113.90	1.7770	18.42	— 3.1180	7.8698	49.1863	201.664	81.58
		13.9404	87.1275	10.9116	78.21	1.8290	13.12	+ 1.1998	12.1114	75.6973	310.359	86.88
Tanaka . .	*Idem*	14.1636	88.5225	11.3300	79.99	2.8416	20.06	— 0.0080	11.3220	70.7625	290.126	79.94
		9.6870	60.5438	11.3256	116.88	2.3205	23.95	— 3.9591	7.3665	46.0406	188.766	76.06
		14.3868	89.9175	10.8547	75.44	2.4084	16.74	+ 1.1123	11.9784	74.8650	304.947	83.26

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Higuchi .	Riz cuit . . . Boiled rice . .	475.79	1.0958	0.23	474.69	1946.229	99.77
	Gruau de riz . Rice gruel . .	156.07	0.9881	0.63	155.08	635.828	99.37
	Riz cuit . . . Boiled rice . .	510.86	1.0532	0.21	509.81	2090.221	99.79
Momoyeda	*Idem*	483.33	1.6790	0.34	481.65	1974.765	99.66
		156.07	1.3245	0.84	154.75	634.475	99.16
		483.33	1.1485	0.24	482.18	1976.938	99.76
Tanaka .	*Idem*	510.86	1.5145	0.29	509.35	2088.335	99.71
		159.23	1.4420	0.90	157.79	646.939	99.09
		528.40	1.3203	0.24	527.08	2161.028	99.76

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Higuchi .	Riz cuit . . . Boiled rice . .	19.74	1.8598	9.42	17.88	166.284	90.58
	Gruau de riz . Rice gruel . .	17.18	1.4848	8.64	15.70	146.010	91.36
	Riz cuit . . . Boiled rice . .	20.02	1.6414	8.19	18.38	170.934	91.81
Momoyeda	*Idem*	19.88	2.2727	11.43	17.61	163.773	88.57
		17.18	1.3546	7.88	15.83	147.219	92.12
		19.88	1.5026	7.55	18.38	170.934	92.45
Tanaka	*Idem*	20.02	2.7287	13.63	17.29	160.797	86.37
		17.21	1.8624	10.82	15.35	142.755	89.18
		20.16	1.8730	9.29	18.29	170.094	90.71

Digestibility and Utilisation of Crude Ash.

Sujets / Subject	Période / Period	Absorption des cendres Moy. journ. (gr.) / Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière / Ash in fæces Average per day		Pourcentage d'absorption / % of absorption
			Quantité (gr.) / Quantity (gms.)	% de la quantité absorbée / % against intake	
Higuchi .	Riz cuit . . . . . / Boiled rice	24.35	2.9004	11.91	88.09
	Gruau de riz . . . . / Rice gruel	23.11	2.6953	11.66	88.34
	Riz cuit . . . . . / Boiled rice	24.48	2.9975	12.24	87.76
Momoyeda	*Idem*	24.42	3.2261	13.21	86.79
		23.11	2.5785	11.16	88.84
		24.42	2.7722	11.35	88.65
Tanaka .	*Idem*	24.48	4.1729	17.04	82.96
		23.12	3.0985	13.40	86.60
		24.55	3.8437	15.65	84.35

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets / Subject	Période / Period	Absorption des calories Moyenne journalière / Calories intake Average per day		Utilisation des calories / Calories utilisation		% de la quantité de calories absorbée / % against calories intake
		Calories totales / Total calories	Par kg. du poids / Per kg. of body weight	Calories totales / Total calories	Par kg. du poids / Per kg. of body weight	
Higuchi .	Riz cuit . . . . / Boiled rice . . .	2485.824	47.59	2417.335	46.28	97.24
	Gruau de riz . . / Rice gruel . . .	1046.860	20.40	990.057	19.30	94.61
	Riz cuit . . . . / Boiled rice . . .	2613.654	51.28	2577.322	49.99	97.60
Momoyeda	*Idem*	2564.760	44.88	2436.790	42.64	95.23
		1046.860	18.40	983.358	17.28	93.48
		2564.760	45.43	2458.231	43.54	95.84
Tanaka .	*Idem*	2643.654	49.47	2539.258	47.77	96.56
		1061.125	20.02	978.460	18.46	92.21
		2722.590	51.37	2636.069	49.74	96.82

Digestibility and Utilisation of Each Constituent.

Période Period	Azote total Total nitrogen %	Hydrates de carbone (comme le glycose) Carbo-hydrate as glucose %	Graisse brute Crude fat %	Cendres brutes Crude ash %	Calories %
Riz cuit — Boiled rice	83.337	99.713	88.507	85.947	96.343
Gruau de riz—Rice gruel	80.620	99.207	90.887	87.927	93.433
Riz cuit — Boiled rice	85.753	99.770	91.657	86.920	96.753

Conclusion.

1. The digestibility and utilisation of total nitrogen, carbohydrates and crude fat were better when ordinary boiled rice was used than when stewed rice was used, but in the case of crude ash, they were worse. The quantity of energy supplied was greater during the boiled rice period.

2. When similar side dishes were eaten, we found that more stewed rice was eaten than boiled rice; but if we compared the amounts in terms of uncooked rice we found the real quantity of stewed rice was much smaller than that of boiled rice. The required amount of energy could not be supplied by the stewed rice.

3. The daily amounts of urine increased remarkably during the stewed rice period; two specimens showed an alkaline reaction.

4. The ratio of urea nitrogen to total urine nitrogen was less during the stewed rice period.

5. The output of fæces was the same in each period.

Experiment IV.

Comparison of the Digestibility and Utilisation of "Ojiya" and Ordinary Boiled Rice.

For the preparation of " Ojiya ", 963 gms. of polished rice were washed and boiled with 4,000 cc. of water. When the boiling-point was reached, 80 gms. of " miso " were added and the mixture was then cooked. We obtained 3,860 gms. of " Ojiya ".

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
		Mai-May	(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Kayano	Riz cuit Boiled rice	24	9.9709	8.2046	82.39	0.8326	8.35	0.1959	1.87	0.0289	0.29	0.1536	1.54	0.5236	5.25	0.0090	0.09
		25	10.2463	8.5276	83.23	0.5474	5.34	0.2020	1.97	0.0268	0.26	0.2276	2.22	0.5326	5.20	0.0101	0.10
		Moy-Aver	10.1086	8.3661	82.81	0.6900	6.85	0.1989	1.92	0.0279	0.28	0.1906	1.88	0.5281	5.23	0.0095	0.10
	Ojiya	26	10.1361	8.1768	80.68	0.4676	4.61	0.1803	1.78	0.0325	0.32	0.1461	1.44	0.5730	5.24	0.0142	0.14
		27	10.7013	8.5066	79.49	0.6159	5.76	0.2201	2.05	0.0296	0.28	0.1405	1.31	0.5190	4.85	0.0135	0.13
		Moy-Aver	10.4187	8.3417	80.08	0.5417	5.19	0.2002	1.91	0.0310	0.30	0.1433	1.37	0.5460	5.04	0.0138	0.14
	Riz cuit Boiled rice	28	10.2463	8.5631	83.51	0.6159	6.01	0.2223	2.17	0.0324	0.32	0.1737	1.69	0.5236	5.13	0.0140	0.14
		29	10.0259	7.8123	77.92	0.6501	6.48	0.2050	2.04	0.0234	0.23	0.1618	1.61	0.5282	5.27	0.0095	0.09
		Moy-Aver	10.1361	8.1877	80.71	0.6330	6.25	0.2136	2.11	0.0279	0.28	0.1677	1.65	0.5259	5.20	0.0117	0.12
Imai	Riz cuit Boiled rice	24	11.6786	8.9921	76.99	0.9580	8.20	0.2050	1.76	0.0324	0.28	0.1707	1.46	0.5282	4.52	0.0095	0.08
		25	10.0811	8.4897	84.21	0.5588	5.54	0.1868	1.85	0.0296	0.29	0.1650	1.64	0.5190	5.14	0.0135	0.13
		Moy-Aver	10.8799	8.7409	80.60	0.7584	6.87	0.2959	1.81	0.0310	0.29	0.1679	1.55	0.5236	4.83	0.0115	0.11
	Ojiya	26	10.7013	8.6557	79.91	0.6957	6.50	0.1847	1.73	0.0324	0.30	0.1517	1.42	0.5103	4.76	0.0088	0.08
		27	11.5684	8.4559	73.09	0.7413	6.41	0.2020	1.74	0.0317	0.27	0.1563	1.35	0.5103	4.41	0.0133	0.11
		Moy-Aver	11.1349	8.5558	76.50	0.7185	6.45	0.1934	1.74	0.0321	0.29	0.1540	1.39	0.5103	4.59	0.0110	0.09
	Riz cuit Boiled rice	28	10.6592	8.9238	83.72	0.6387	5.89	0.1989	1.86	0.0330	0.31	0.1681	1.58	0.5147	4.82	0.0089	0.09
		29	10.3565	8.1636	78.82	0.7299	7.05	0.1686	1.62	0.0275	0.26	0.1729	1.67	0.5474	5.28	0.0101	0.09
		Moy-Aver	10.5079	8.5437	81.27	0.6843	6.47	0.1837	1.74	0.0302	0.29	0.1705	1.63	0.5310	5.05	0.0095	0.09
Shimizu	Riz cuit Boiled rice	24	11.3481	8.8690	78.15	0.8310	7.32	0.1989	1.75	0.0296	0.26	0.1479	1.30	0.5149	4.53	0.0135	0.12
		25	11.6786	9.6634	82.74	0.6272	5.37	0.2171	1.86	0.0310	0.27	0.1981	1.69	0.5326	4.56	0.0101	0.09
		Moy-Aver	11.5134	9.2662	80.44	0.7291	6.34	0.2080	1.81	0.0303	0.27	0.1730	1.49	0.5238	4.55	0.0118	0.10
	Ojiya	26	12.3397	9.1146	73.86	0.6729	5.45	0.2171	1.76	0.0329	0.25	0.1686	1.36	0.6326	4.31	0.0149	0.12
		27	13.0007	10.2460	78.81	0.8211	6.31	0.2080	1.59	0.0365	0.28	0.1742	1.34	0.5236	4.02	0.0140	0.11
		Moy-Aver	12.6702	9.6803	76.34	0.7470	5.88	0.2125	1.77	0.0347	0.27	0.1714	1.35	0.5281	4.17	0.0144	0.12

(Continuation.)

Sujets Subjects	Période Period	Date	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH³ Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
		Mai-May	(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Schimizu	Riz cuit Boiled rice	28	12.2285	9.6143	78.62	0.5930	4.85	0.2201	1.79	0.0358	0.29	0.1793	1.46	0.5236	4.28	0.0140	0.11
		29	13.2211	10.5127	79.51	0.7755	5.86	0.2141	1.62	0.0351	0.27	0.1935	1.46	0.5376	4.06	0.0098	0.07
		Moy-Aver	12.7248	10.0914	79.07	0.6842	5.35	0.2171	1.71	0.0355	0.28	0.1864	1.46	0.5306	4.17	0.0119	0.10
Tanaka	Riz cuit Boiled rice	24	9.3649	7.7529	82.78	0.7869	8.40	0.1868	1.99	0.0168	0.28	0.2232	2.38	0.4934	5.27	0.0084	0.09
		25	9.4751	7.6079	80.29	0.5816	6.14	0.2020	2.13	0.0303	0.32	0.2219	2.34	0.4934	5.21	0.0084	0.09
		Moy-Aver	9.4200	7.7304	81.54	0.6842	7.27	0.1944	2.06	0.0286	0.30	0.2226	2.36	0.4934	5.24	0.0084	0.09
	Ojiya	26	9.9158	7.4922	75.56	0.6159	6.26	0.1989	2.01	0.0324	0.33	0.2248	2.26	0.4704	4.74	0.0074	0.07
		27	11.1177	9.1065	81.91	0.7299	6.56	0.2080	1.87	0.0330	0.29	0.1967	1.77	0.4856	4.36	0.0120	0.18
		Moy-Aver	10.5168	8.2994	78.74	0.6729	6.39	0.2034	1.94	0.0327	0.31	0.2107	2.02	0.4780	4.55	0.0097	0.13
	Riz cuit Boiled rice	28	10.7013	8.7911	82.15	0.6615	6.18	0.1929	1.80	0.0317	0.29	0.1905	1.78	0.4817	4.50	0.0117	0.11
		29	9.9158	7.7204	77.85	0.8212	8.28	0.1686	1.70	0.0275	0.28	0.2219	2.24	0.5018	5.06	0.0085	0.08
		Moy-Aver	10.3086	8.2558	80.00	0.7914	7.23	0.1857	1.75	0.0296	0.29	0.2062	2.01	0.4917	4.78	0.0101	0.10
Kato	Riz cuit Boiled rice	24	12.2846	9.8048	79.81	0.8326	6.77	0.1847	1.50	0.0310	0.25	0.1991	1.62	0.5427	4.41	0.0149	0.12
		25	11.5600	9.2493	80.16	0.6729	5.82	0.2323	2.01	0.0296	0.25	0.2048	1.77	0.5846	5.05	0.0175	0.15
		Moy-Aver	11.9223	9.5088	79.98	0.7527	6.29	0.2085	1.75	0.0303	0.25	0.2019	1.69	0.5637	4.73	0.0162	0.14
	Ojiya	26	11.5684	8.7580	75.71	0.6272	5.42	0.2232	1.93	0.0317	0.27	0.1742	1.51	0.5575	4.82	0.0159	0.13
		27	12.0091	8.8033	73.35	0.7853	6.54	0.1868	1.55	0.0333	0.27	0.1563	1.30	0.5792	4.82	0.0113	0.09
		Moy-Aver	11.7888	8.7807	74.53	0.7062	5.98	0.2050	1.74	0.0325	0.27	0.1652	1.41	0.5684	4.82	0.0136	0.11
	Riz cuit Boiled rice	28	12.1744	9.4973	78.01	0.6729	5.52	0.2020	1.66	0.0351	0.29	0.2017	1.65	0.5903	4.85	0.0178	0.14
		29	11.0176	8.5718	77.91	0.6387	5.50	0.1686	1.45	0.0227	0.19	0.2064	1.78	0.5680	4.89	0.0109	0.09
		Moy-Aver	11.5960	9.0346	77.96	0.6558	5.51	0.1853	1.56	0.0289	0.24	0.2041	1.67	0.5796	4.87	0.0143	0.12

Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Kayano			Imai		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz cuit Boiled rice	Mai-May 24	1.7282	1.0440	20.0	1.7872	1.4964	21.5
	25	1.6198	1.5312	19.9	1.6810	1.5138	16.6
	Moyenne –Aver.	1.6740	1.2876	20.0	1.7341	1.5051	19.1
Ojiya	26	1.9826	1.6109	22.9	1.8379	1.2528	20.8
	27	1.8043	1.3746	19.9	1.9374	1.4610	16.4
	Moyenne –Aver.	1.8935	1.4927	21.4	1.8876	1.3569	18.6
Riz cuit Boiled rice	28	1.7234	1.7748	15.7	1.7726	1.7052	21.2
	29	1.7213	1.5886	22.1	1.6535	1.5312	19.9
	Moyenne –Aver.	1.7224	1.6817	18.9	1.7130	1.6682	20.6

Period Période	Date	Shimizu			Tanaka			Kato		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz cuit Boiled rice	Mai-May 24	1.8018	1.6872	26.0	1.7111	1.5138	22.8	2.0364	1.4442	17.6
	25	2.0718	1.6872	21.0	1.6805	1.6704	13.6	1.8737	1.6008	19.6
	Moyenne –Aver.	1.9368	1.6872	23.5	1.6958	1.5921	18.2	1.9551	1.5725	18.6
Ojiya	26	2.1582	1.7748	23.1	1.6891	1.2528	17.6	2.1104	1.6182	19.9
	27	2.1325	1.7922	19.4	1.8935	1.6356	19.4	2.1744	1.4762	20.8
	Moyenne –Aver.	2.1453	1.7835	21.3	1.7413	1.4442	18.5	2.1424	1.5472	20.4
Riz cuit Boiled rice	28	2.1356	2.2446	19.5	1.7255	1.9488	19.7	2.1054	1.7052	21.8
	29	2.1232	2.1750	18.2	1.6617	1.7748	20.8	1.7789	1.5660	16.4
	Moyenne –Aver.	2.1244	2.2098	18.9	1.6936	1.8628	20.3	1.9421	1.6356	14.1

Nitrogen Balance: the Digestibility and Utilisation, and Caloric Value.

Sujets / Subject	Période / Period	Absorption d'azote Moyenne journalière — N. intake Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Azote trouvé dans l'urine Moyenne journalière — N. in urine Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Azote trouvé dans les selles Moyenne journalière — N. in fæces Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière — Absorption Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	Pourcentage d'absorption % of absorption
Kayano . .	Riz cuit . . . . Boiled rice . . .	14.0388	87.7425	10.1086	72.00	1.8723	13.33	+ 2.0579	12.1665	76.0406	311.766	86.67
	Ojiya	11.6362	72.7263	10.4187	89. 53	1.6091	13.83	— 0.3916	10.0271	62.6694	256.945	86.17
	Riz cuit . . . . Boiled rice . . .	14.0388	87.7425	10.1361	72.20	1.8032	12.85	+ 2.0995	12.2356	76.4727	313.538	87.15
Imai . . .	*Idem*	15.9316	99.5725	10.8799	68.29	2.0925	13.14	+ 2.9592	13.8391	86.4944	354.627	86.86
		12.0458	75.2863	11.1349	92.43	1.8756	15.57	— 0.9547	10.1702	63.5638	260.612	84.43
		15.6950	98.0938	10.5079	66.95	2.2316	14.22	+ 2.9555	13.4634	84.1463	345.000	85.78
Shimizu . .	*Idem*	15.6950	98.0938	11.5134	73.35	2.4519	15.62	+ 1.7297	13.2431	82.7694	339.355	84.38
		11.4314	71.4463	12.6702	110.83	1.9118	16.72	— 3.1506	9.5196	59.4975	243.940	83.28
		15.9316	99.5725	12.7248	79.87	1.9377	12.16	+ 1.2691	13.9939	87.4619	358.594	87.84
Tanaka . .	*Idem*	14.0388	87.7425	9.4200	67.10	2.1840	14.84	+ 2.4338	11.8538	74.0863	303.754	85.16
		11.6362	72.7263	10.5168	90.39	2.0218	17.37	— 0.9024	9.6144	60.0900	246.369	82.63
		14.7486	92.1788	10.3086	69.89	2.1228	14.39	+ 2.3172	12.6258	78.9113	323.536	85.61
Kato . . .	*Idem*	15.2228	95.1425	11.9223	78.32	2.2276	14.63	+ 1.7029	12.9952	81.2200	333.002	85.37
		11.5338	72.0863	11.7888	102.21	2.0931	18.06	— 2.3481	9.4407	59.0044	241.918	81.94
		15.4584	96.6150	11.5960	75.01	2.1225	13.73	+ 1.7399	13.3359	83.3494	341.733	86.27

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Averagé per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Kayano .	Riz cuit . . . Boiled rice . .	489.11	1.0851	0.22	488.02	2000.882	99.78
	Ojiya	239.27	0.7440	0.31	238.53	977.973	99.69
	Riz cuit . . . Boiled rice . .	489.11	1.1867	0.24	487.92	2000.472	99.76
Imai . .	*Idem*	633.83	1.5509	0.24	632.28	2592.348	99.76
		262.31	1.4008	0.53	260.91	1069.731	99.47
		615.74	2.2053	0.35	613.53	2515.473	99.65
Shimizu .	*Idem*	615.74	1.5964	0.25	614.14	2517.974	99.75
		227.75	1.3607	0.60	226.39	928.199	99.40
		633.83	1.8292	0.28	632.00	2591.200	99.72
Tanaka .	*Idem*	489.11	1.8314	0.38	487.28	1997.818	99.62
		239.27	1.1210	0.47	238.15	976.415	99.53
		543.38	1.5042	0.27	541.88	2221.708	99.73
Kato . .	*Idem*	579.56	1.4760	0.25	578.08	2370.128	99.75
		233.51	1.4485	0.61	232.06	951.446	99.39
		597.65	1.6461	0.25	596.00	2443.600	99.75

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Kayano .	Riz cuit . . . Boiled rice . .	20.22	1.7427	8.61	18.48	171.864	91.39
	Ojiya	19.42	0.9906	5.10	18.43	171.399	94.90
	Riz cuit . . . Boiled rice . .	20.22	1.8190	9.00	18.40	171.120	91.00
Imai . .	*Idem*	21.50	1.7736	8.24	19.73	183.489	91.76
		19.80	1.4211	7.17	18.38	170.934	92.83
		21.34	2.1220	9.94	19.22	178.746	90.06
Shimizu .	*Idem*	21.34	2.0558	9.63	19.28	179.304	90.37
		19.23	1.5849	8.24	17.65	164.145	91.76
		21.50	1.7531	8.15	19.75	183.675	91.85
Tanaka	*Idem*	20.22	2.2533	11.14	17.97	167.121	88.86
		19.42	1.6207	8.34	17.80	165.540	91.66
		20.70	2.2612	10.92	18.44	171.492	89.08
Kato . .	*Idem*	21.02	2.0746	9.86	18.95	176.235	90.14
		19.33	1.7462	9.03	17.58	163.494	90.97
		21.18	2.1059	9.92	19.07	177.351	90.08

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Kayano .	Riz cuit.	24.71	2.7690	11.20	88.80
	Boiled rice				
	Ojiya	26.31	1.5840	6.02	93.98
	Riz cuit.	24.71	2.7144	10.94	89.06
	Boiled rice				
Imai . .	*Idem*	25.35	3.2832	12.94	87.06
		26.75	3.4366	12.89	87.10
		25.27	3.9650	15.69	84.31
Shimizu. .	*Idem*	25.27	2.8869	11.42	88.58
		26.09	2.4719	9.47	90.53
		25.35	2.4247	9.57	90.43
Tanaka .	*Idem*	24.71	3.0643	12.43	87.57
		26.31	3.1161	11.84	88.16
		24.95	3.4397	13.79	86.21
Kato . . .	*Idem*	25.11	2.8178	11.22	88.78
		26.20	3.1014	11.83	88.17
		25.19	3.0379	12.09	87.91

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Calories utilisation		% de la quantité de calories absorbée % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Kayano .	Riz cuit	2553.141	52.32	2484.512	50.91	97.31
	Boiled rice . . .					
	Ojiya	1459.791	30.22	1406.317	29.11	96.33
	Riz cuit	2553.141	52.37	2485.130	50.98	97.34
	Boiled rice . . .					
Imai . . .	*Idem* .	3206.900	63.53	3130.464	62.01	97.61
		1568.285	31.13	1501.277	30.00	96.37
		3125.180	62.38	3039.219	60.66	97.24
Shimizu .	*Idem*	3125.180	58.36	3036.633	56.71	97.17
		1405.544	26.44	1336.284	25.15	95.12
		3206.900	60.18	3133.469	58.81	97.72
Tanaka .	*Idem*	2553.141	54.73	2468.723	52.92	96.69
		1459.791	31.39	1388.324	29.86	95.13
		2798.301	60.01	2716.736	58.36	97.25
Kato . .	*Idem*	2961.766	55.38	2879.365	53.84	97.22
		1432.714	26.83	1356.858	25.41	94.71
		3043.470	56.78	2962.684	55.27	97.34

Digestibility and Utilisation of Each Constituent.

Période Period	Azote total Total nitrogen %	Hydrates de carbone comme le glycose Carbo-hydrate as glucose %	Graisse brute Crude fat %	Cendres brutes Crude ash %	Calories %
Riz cuit — Boiled rice	85.688	99.732	90.504	88.158	97.200
Ojiya	83.690	99.496	92.424	89.548	95.532
Riz cuit — Boiled rice	86.530	99.722	90.414	87.584	97.378

Conclusion.

1. The digestibility and utilisation of total nitrogen and carbohydrates were better when ordinary boiled rice was used than when " Ojiya " was used, but in the case of crude ash and crude fat they were worse. The amount of energy supplied was greater during the boiled-rice period.

2. More " Ojiya " was eaten than boiled rice; but if we compared the amounts in terms of uncooked rice, we found the real quantity of " Ojiya " was much smaller than that of boiled rice. The required amount of energy could not be supplied by " Ojiya ".

3. The daily amounts of urine increased during the " Ojiya " period.

4. The ratio of urea nitrogen to total nitrogen in the urine was slightly less during the " Ojiya " period.

5. There was no great difference in the output of fæces during the two periods.

Experiment V.

Comparison of the Digestibility and Utilisation of " Sushi " and Ordinary Boiled Rice.

For the preparation of " Sushi " rice was cooked in the usual way and 180 cc. of vinegar, 50 gms. of sugar and 5 gms. of NaCl were then added: the mixture was then cooled. We obtained an average of 2,510 gms. of " Sushi ".

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date Juin-June	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	(%)	Azote de NH^3 Ammonia N. (g)	(%)	Azote de l'acide urique Uric acid N. (g)	(%)	Azote des bases puriques Purin base N. (g)	(%)	Azote des acides aminés Amino acid N. (g)	(%)	Azote de la créatinine Creatinin N. (g)	(%)	Azote de la créatine Creatin N. (g)	(%)
Nakamura	Riz cuit Boiled rice	21	11.8439	10.2740	86.74	0.6045	5.10	0.2170	1.83	0.0264	0.22	0.1794	1.51	0.6022	5.08	0.0669	0.56
		22	12.8121	10.6218	82.99	0.5816	4.53	0.2340	1.90	0.0174	0.13	0.1728	1.34	0.5790	4.51	0.0901	0.70
		Moy-Aver	12.3280	10.4479	84.86	0.5930	4.82	0.2255	1.87	0.0219	0.17	0.1761	1.43	0.5906	4.80	0.0785	0.63
	Sushi	23	12.3317	9.9007	80.28	0.6273	5.08	0.2020	1.63	0.0208	0.16	0.1661	1.34	0.5846	4.74	0.0696	0.56
		24	11.4835	8.7553	76.24	0.7755	6.73	0.2092	1.82	0.0188	0.16	0.1702	1.48	0.5846	5.09	0.0427	0.37
		Moy-Aver	11.9076	9.3280	78.26	0.7014	5.91	0.2056	1.73	0.0198	0.16	0.1682	1.41	0.5846	4.92	0.0562	0.47
	Riz cuit Boiled rice	25	12.5548	10.3337	82.31	0.7299	5.81	0.2266	1.80	0.0230	0.18	0.1629	1.29	0.6022	4.79	0.0596	0.47
		26	11.0389	8.6667	78.51	0.6957	6.30	0.1929	1.74	0.0244	0.22	0.1558	1.41	0.6022	5.45	0.0384	0.34
		Moy-Aver	11.7969	9.5502	80.41	0.7128	6.06	0.2098	1.76	0.0237	0.20	0.1594	1.35	0.6022	5.12	0.0490	0.41
Tanaka	Riz cuit Boiled rice	21	9.9709	7.9198	79.43	0.6616	6.63	0.2200	2.21	0.0307	0.31	0.2129	2.13	0.5790	5.81	0.0355	0.35
		22	10.9389	8.7465	80.00	0.8440	7.72	0.2444	2.23	0.0251	0.23	0.2119	1.94	0.5790	5.29	0.0232	0.21
		Moy-Aver	10.4549	8.8332	79.72	0.7528	7.18	0.2322	2.22	0.0279	0.27	0.2124	2.04	0.5790	5.55	0.0294	0.33
	Sushi	23	10.7037	8.0017	74.76	0.7641	7.14	0.2171	2.03	0.0209	0.19	0.2048	1.91	0.5960	5.57	0.0246	0.23
		24	10.7601	7.9987	74.34	0.7755	7.27	0.2189	2.03	0.0251	0.23	0.1867	1.73	0.6022	5.59	0.0186	0.17
		Moy-Aver	10.7319	8.0002	74.55	0.7698	7.21	0.2180	2.03	0.0230	0.21	0.1958	1.82	0.5991	5.58	0.0216	0.20
	Riz cuit Boiled rice	25	10.5812	8.1733	77.24	0.7755	7.33	0.2141	2.02	0.0272	0.25	0.1474	1.39	0.5790	5.47	0.0232	0.22
		26	9.5331	7.4048	77.67	0.7071	7.41	0.1929	2.02	0.0230	0.24	0.1836	1.92	0.5790	6.07	0.0232	0.22
		Moy-Aver	10.0572	7.7891	77.46	0.7413	7.37	0.2035	2.02	0.0251	0.25	0.1655	1.66	0.5790	5.77	0.0232	0.22
Imai	Riz cuit Boiled rice	21	11.5684	8.9463	77.34	0.7071	6.11	0.2140	1.85	0.0181	0.16	0.1736	1.50	0.4933	4.26	0.0126	0.11
		22	12.1544	9.7918	80.56	0.7755	6.38	0.2262	1.86	0.0307	0.25	0.1774	1.46	0.4779	3.90	0.0117	0.09
		Moy-Aver	11.8614	9.3691	78.95	0.7413	6.25	0.2201	1.86	0.0244	0.21	0.1755	1.48	0.4856	4.08	0.0122	0.10
	Sushi	23	11.9347	10.9144	74.61	0.8326	6.97	0.1838	1.54	0.0201	0.17	0.1771	1.48	0.5102	4.27	0.0133	0.11
		24	12.8121	10.0055	78.89	0.7527	5.87	0.1874	1.46	0.0307	0.23	0.1757	1.37	0.5190	4.05	0.0091	0.07
		Moy-Aver	12.3734	9.5115	76.75	0.7927	6.42	0.1856	1.50	0.0254	0.20	0.1764	1.43	0.5146	4.16	0.0112	0.09

(Continuation.)

Sujets Subjects	Période Period	Date Juin-June	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	(%)	Azote de NH³ Ammonia N. (g)	(%)	Azote de l'acide urique Uric acid N. (g)	(%)	Azote des bases puriques Purin base N. (g)	(%)	Azote des acides aminés Amino acid N. (g)	(%)	Azote de la créatinine Creatinin N. (g)	(%)	Azote de la créatine Creatin N. (g)	(%)
Imai	Riz cuit Boiled rice	25	11.6966	10.0996	86.34	0.5930	5.07	0.2050	1.75	0.0230	0.19	0.1693	1.44	0.4652	3.97	0.0185	0.15
		26	11.6966	9.4837	81.08	0.7527	6.43	0.1958	1.67	0.0250	0.21	0.1780	1.52	0.4740	4.05	0.0154	0.13
		Moy-Aver	11.6966	9.7917	83.71	0.6729	5.75	0.2004	1.71	0.0240	0.20	0.1737	1.48	0.4696	4.01	0.0170	0.14
Shimizu	Riz cuit Boiled rice	21	10.1912	8.3527	81.96	0.4787	4.70	0.1929	1.90	0.0272	0.22	0.1849	1.81	0.4816	4.72	0.0117	0.12
		22	11.9412	8.8809	74.37	0.6957	5.82	0.2223	1.86	0.0306	0.25	0.1832	1.53	0.5376	4.50	0.0098	0.08
		Moy-Aver	11.0662	8.6168	78.16	0.5872	5.26	0.2076	1.88	0.0289	0.23	0.1841	1.67	0.5096	4.61	0.0108	0.10
	Sushi	23	13.6029	11.0202	81.01	1.0036	7.37	0.2262	1.66	0.0286	0.21	0.1605	1.18	0.5474	4.02	0.0101	0.07
		24	11.8639	9.0443	76.23	0.6957	5.85	0.1994	1.90	0.0306	0.25	0.1493	1.26	0.5376	4.85	0.0098	0.08
		Moy-Aver	12.7334	10.0323	78.62	0.8497	6.61	0.2133	1.78	0.0296	0.23	0.1549	1.22	0.5425	4.94	0.0100	0.08
	Riz cuit Boiled rice	25	12.3698	9.9363	80.41	1.1252	9.09	0.2171	1.76	0.0328	0.26	0.1474	1.19	0.5376	4.34	0.0098	0.08
		26	11.6105	8.8856	76.53	0.8554	7.37	0.1959	1.69	0.0230	0.20	0.1725	1.48	0.4894	4.22	0.0123	0.11
		Moy-Aver	11.9902	9.4160	78.74	0.9903	8.73	0.2065	1.68	0.0279	0.23	0.1600	1.33	0.5135	4.28	0.0110	0.10
Tanaka	Riz cuit Boiled rice	21	9.3649	7.4656	80.78	0.6729	7.18	0.1807	1.92	0.0279	0.28	0.1569	1.66	0.4895	5.22	0.0123	0.13
		22	11.5393	8.5100	73.83	0.9124	7.90	0.2505	2.17	0.0237	0.20	0.1554	1.34	0.4895	4.24	0.0123	0.10
		Moy-Aver	10.4521	7.9878	77.30	0.7927	7.54	0.2156	2.05	0.0258	0.24	0.1562	1.50	0.4895	4.73	0.0123	0.12
	Sushi	23	11.9755	9.0098	75.23	1.1405	9.52	0.1625	1.35	0.0237	0.19	0.1778	1.48	0.4741	3.12	0.0076	0.06
		24	12.1428	8.2169	67.67	1.2659	10.42	0.2067	1.70	0.0313	0.25	0.1537	1.26	0.4933	4.06	0.0126	0.11
		Moy-Aver	12.0592	8.6134	71.45	1.2032	9.97	0.1846	1.53	0.0275	0.22	0.1658	1.37	0.4837	3.59	0.0101	0.09
	Riz cuit Boiled rice	25	10.9274	8.1750	74.79	1.2063	11.04	0.2110	1.92	0.0215	0.19	0.1638	1.49	0.4704	4.28	0.0113	0.10
		26	11.7106	8.6525	73.90	1.0721	9.16	0.1928	1.64	0.0223	0.13	0.1669	1.43	0.4778	4.08	0.0117	0.10
		Moy-Aver	11.3190	8.4138	74.34	1.1392	10.10	0.2019	1.83	0.0219	0.16	0.1654	1.46	0.4741	4.18	0.0115	0.10

Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Nakamura			Tanaka		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz cuit Boiled rice	Juin-June 21	2.0793	1.3670	17.9	1.8098	1.1025	15.7
	22	1.9420	1.5141	19.2	1.7858	1.2789	18.9
	Moyenne — Aver.	2.0107	1.4406	18.6	1.7978	1.1907	17.3
Sushi	23	2.0039	1.4112	23.6	1.8277	1.2936	19.8
	24	1.9058	1.1319	21.4	1.8939	1.2495	24.6
	Moyenne — Aver.	1.9549	1.2716	22.5	1.8608	1.2716	22.2
Riz cuit Boiled rice	25	1.9278	1.3083	20.7	1.6878	1.3377	21.8
	26	1.8729	1.2642	20.8	1.7982	1.1025	16.2
	Moyenne — Aver.	1.9004	1.2863	20.8	1.7430	1.2201	19.0

Période Period	Date	Imai			Shimizu			Tanaka		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz cuit Boiled rice	Juin-June 21	1.9045	1.3818	20.1	1.8958	1.2936	24.0	1.8064	1.5147	21.6
	22	1.8215	1.3230	18.9	1.9101	1.4406	17.3	1.8571	1.5876	14.0
	Moyenne — Aver.	1.8630	1.3524	19.5	1.9030	1.3671	20.7	1.8318	1.5512	17.8
Sushi	23	1.9058	1.2642	20.6	2.1951	1.7787	28.0	1.8736	1.3083	19.9
	24	1.9408	1.3083	22.7	2.1308	1.6023	18.8	2.1719	1.3377	23.0
	Moyenne — Aver.	1.9233	1.2863	21.7	2.1630	1.6905	23.4	2.0228	1.3230	21.5
Riz cuit Boiled rice	25	1.8853	1.4553	17.5	2.2138	1.5288	23.6	1.7824	1.5876	17.9
	26	1.8352	1.4112	16.8	1.9881	1.6758	21.4	1.9769	1.4406	21.4
	Moyenne — Aver.	1.8603	1.4333	17.2	2.1010	1.6023	22.5	1.8797	1.5141	19.7

Sujets / Subject	Période / Period	Absorption d'azote Moyenne journalière — N. intake Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Azote trouvé dans l'urine Moyenne journalière — N. in urine Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Azote trouvé dans les selles Moyenne journalière — N. in fæces Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière — Absorption Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	Pourcentage d'absorption % of absorption
Nakamura .	Riz cuit . . . . Boiled rice . . .	13.7823	86.1394	12.3280	89.74	2.4226	17.57	— 0.9683	11.3597	70.9981	291.092	82.43
	Sushi	14.0452	87.7825	11.9076	84.78	2.1654	15.42	— 0.0278	11.8798	74.2488	304.420	84.58
	Riz cuit . . . . Boiled rice . . .	13.7823	86.1394	11.7969	85.89	2.2766	16.52	— 0.2912	11.5057	71.9106	294.833	83.48
Tanaka . .	*Idem*	14.0283	87.6800	10.4549	74.52	2.8520	20.33	+ 0.7219	11.1768	69.7950	286.160	79 67
		14.0452	87.7825	10.7319	76.41	2.3851	16.98	+ 0.9282	11.6601	72.8756	298.790	83.02
		14.2752	89.2200	10.0572	70.45	2.8491	19.95	+ 1.3689	11.4261	71.4131	292.794	80.05
Imai . . .	*Idem*	15.2610	95.3813	11.8614	77.72	2.6278	17.21	+ 0.7718	12.6332	78.9575	323.726	82.79
		15.5956	97.4725	12.3734	79.34	2.2588	14.48	+ 0.9634	13.3368	83.3550	341.756	85.52
		15.2610	95.3813	11.6966	76.64	2.5336	16.60	+ 1.0308	12.7274	79.5462	326.139	83.40
Shimizu . .	*Idem*	15.2610	95.3813	11.0662	72.51	2.5840	16.93	+ 1.6108	12.6770	79.2312	324.848	83.07
		16.1124	100.7025	12.7334	79.03	2.3116	14.34	+ 1.0674	13.8008	86.2550	353.646	85.66
		15.5075	96.9219	11.9902	77.32	2.5660	16.55	+ 0.9513	12.9415	80.8844	331.626	83.45
T. Tanaka .	*Idem*	14.2752	89.2200	10.4521	73.22	2.8334	19.84	+ 0.9897	11.4418	71.6113	293.606	80.16
		14.7704	92.3150	10.0592	68.10	2.5951	17.57	+ 2.1161	12.1753	76.0956	311.992	82.43
		14.2752	89.2200	11.3190	79.29	2.6654	18.68	+ 0.2908	11.6098	72.5613	297.501	81.32

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Nakamura	Riz cuit . . . Boiled rice . .	503.53	1.2640	0.25	502.27	2059.307	99.75
	Sushi	520.47	1.0704	0.20	519.40	2129.540	99.80
	Riz cuit . . . Boiled rice . .	503.53	1.3052	0.26	502.22	2059.102	99.74
Tanaka .	*Idem*	523.92	1.3003	0.25	522.62	2142.742	99.75
		520.47	1.2595	0.24	519.21	2128.761	99.76
		544.31	1.8264	0.33	542.48	2224.168	99.67
Imai . .	*Idem*	625.87	1.5357	0.24	624.33	2559.753	99.76
		647.43	1.4149	0.22	646.02	2648.682	99.78
		625.87	1.8994	0.30	623.97	2558.277	99.70
Shimizu .	*Idem*	625.87	1.3948	0.22	624.48	2560.368	99.78
		689.75	1.6326	0.23	688.12	2821.292	99.77
		646.26	1.5583	0.24	644.70	2643.270	99.76
T.Tanaka	*Idem*	544.31	1.2049	0.23	543.11	2226.751	99.78
		583.95	1.1856	0.20	582.76	2389.316	99.80
		544.31	1.4325	0.26	542.90	2225.890	99.74

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Nakamura	Riz cuit . . . Boiled rice . .	20.67	2.3409	11.32	18.33	170.469	88.68
	Sushi	18.91	1.3422	7.09	17.57	163.401	92.91
	Riz cuit . . . Boiled rice . .	20.67	1.6420	7.94	19.03	176.979	92.06
Tanaka	*Idem*	20.87	2.1407	10.25	18.73	174.189	89.75
		18.91	1.4048	7.43	17.51	162.843	92.57
		21.06	2.0185	9.58	19.04	177.072	90.42
Imai . .	*Idem*	21.84	1.7689	8.10	20.07	186.651	91.90
		19.60	1.4280	7.28	18.17	168.981	92.72
		21.84	1.9105	8.78	19.93	185.349	91.26
Shimizu .	*Idem*	21.84	1.8735	8.58	19.97	185.721	91.42
		19.83	1.5606	7.86	18.27	169.911	92.14
		22.04	2.0499	9.76	19.99	185.907	90.24
T. Tanaka	*Idem*	21.06	2.3361	11.09	18.72	174.096	88.91
		19.26	1.9378	10.05	17.32	161.076	89.95
		21.06	2.2877	10.86	18.77	174.561	89.14

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Nakamura	Riz cuit.	24.88	3.6130	14.52	85.48
	Boiled rice				
	Sushi	25.76	2.8045	10.88	89.12
	Riz cuit.	24.88	3.1906	12.82	87.18
	Boiled rice				
Tanaka .	*Idem*	24.98	2.9560	11.83	88.17
		25.76	2.7328	10.61	89.39
		25.07	3.6425	14.53	85.47
Imai . .	*Idem*	25.45	2.8152	11.06	88.94
		26.57	2.6923	10.13	89.87
		25.45	3.4061	13.38	86.62
Shimizu. .	*Idem*	25.45	2.7086	11.04	88.96
		26.84	3.1681	11.80	88.20
		25.55	3.5641	13.91	86.09
T. Tanaka.	*Idem*	25.07	3.2411	12.92	87.08
		26.57	3.1927	12.01	87.99
		25.07	3.2461	12.95	87.05

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Caloric utilisation		% de la quantité de calories absorbée % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Nakamura	Riz cuit . . . . Boiled rice . . .	2609.875	46.86	2520.868	45.26	96.59
	Sushi	2669.698	47.93	2597.361	46.63	97.29
	Riz cuit . . . . Boiled rice . . .	2609.875	46.94	2530.914	45.52	96.97
Tanaka. .	*Idem*	2711.651	51.80	2603.091	49.72	95.98
		2669.698	50.96	2590.394	49.45	97.03
		2793.329	53.31	2694.034	51.41	96.43
Imai. . .	*Idem*	3160.242	62.70	3070.130	60.91	97.14
		3236.380	63.92	3159.419	62.40	97.62
		3160.242	62.33	3069.765	60.55	97.30
Shimizu .	*Idem*	3160.242	58.47	3070.937	56.82	97.18
		3425.374	63.30	3344.849	61.83	97.68
		3252.018	60.11	3160.803	58.42	97.19
T. Tanaka	*Idem*	2793.329	60.03	2694.453	57.01	96.47
		2951.804	63.37	2862.384	61.45	96.97
		2793.329	60.00	2697.952	57.90	96.50

Digestibility and Utilisation of Each Constituent.

Période Period	Azote total Total nitrogen %	Hydrates de carbone comme le glycose Carbo-hydrate as glucose %	Graisse brute Crude fat %	Cendres brutes Crude ash %	Calories %
Riz cuit — Boiled rice	81.624	99.764	90.132	87.726	96.672
Sushi	84.242	99.782	92.058	88.914	97.318
Riz cuit — Boiled rice	82.340	99.722	90.624	86.482	96.878

Conclusion.

1. The digestibility and utilisation of each constituent were better when we used polished rice as " Sushi " than when we used it as boiled rice. The amount of energy supplied was rather more during the " Sushi " period.

2. The quantity of " Sushi " eaten was almost equal to that of ordinary boiled rice. The appetite was the same during the two periods.

3. The ratio of total nitrogen in the urine to nitrogen intake was greater during the " Sushi " period, but the individual nitrogenous compounds in the urine varied but little except in the case of the urea nitrogen, the ratio of which to the total urine nitrogen was slightly smaller during the " Sushi " period.

4. The output of fæces was less during the " Sushi " period than during the boiled rice period.

Experiment VI (*a*).

Comparison of the Digestibility and Utilisation of " Akanogohan " and Ordinary Boiled Rice.

For the preparation of " Akanogohan " 1,171 gms. of washed polished rice were cooked with 1,600 cc. of water and 400 cc. of juice prepared from boiled red beans; we obtained in this way 3,023 gms. of " Akanogohan ".

For the preparation of the juice of boiled red beans 1,470 gms. of red beans were washed and boiled in 10,000 cc. of water for one hour. The juice was squeezed through a cotton cloth. The beans were again boiled for an hour and a-half, and the juice extracted as before. We obtained altogether 3,300 cc. of juice.

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
		Nov.	(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Higuchi	Riz cuit Boiled rice	2	10.0980	8.7996	87.14	0.4787	4.74	0.1807	1.79	0.0223	0.22	0.1712	1.69	0.5018	4.96	0.0129	0.12
		3	12.9336	10.4032	80.43	0.5360	4.14	0.2354	1.82	0.0250	0.18	0.1666	1.29	0.6022	4.65	0.0123	0.09
		Moy-Aver	11.5158	9.6014	83.78	0.5073	4.44	0.2081	1.80	0.0237	0.20	0.1689	1.49	0.5520	4.80	0.0126	0.10
	Akanogohan	4	12.5089	10.3101	82.42	0.5474	4.37	0.2020	1.61	0.0203	0.16	0.1772	1.41	0.5474	4.37	0.0101	0.08
		5	11.7156	10.0120	84.60	0.6295	5.37	0.2232	1.90	0.0270	0.23	0.1801	1.53	0.5576	4.75	0.0159	0.13
		Moy-Aver	12.1123	10.1611	83.51	0.5884	4.87	0.2126	1.75	0.0237	0.19	0.1786	1.47	0.5525	4.56	0.0130	0.10
	Riz cuit Boiled rice	6	12.2760	10.1638	82.79	0.6615	5.38	0.2446	1.99	0.0236	0.19	0.1841	1.49	0.5576	4.53	0.0159	0.13
		7	13.4442	11.5109	85.62	0.7413	5.51	0.2171	1.61	0.0263	0.19	0.1773	1.31	0.5524	4.10	0.0103	0.08
		Moy-Aver	12.8601	10.8374	84.21	0.7014	5.44	0.2309	1.80	0.0250	0.19	0.1812	1.40	0.5550	4.31	0.0131	0.10
Tanaka	Riz cuit Boiled rice	2	8.9077	7.3339	82.33	0.5816	6.52	0.2719	3.05	0.0385	0.43	0.1654	1.85	0.6022	6.76	0.0669	0.75
		3	13.3801	11.1938	83.66	0.5474	4.09	0.2792	2.08	0.0358	0.26	0.1609	1.20	0.5961	4.45	0.0729	0.54
		Moy-Aver	11.1439	9.2639	82.99	0.5645	5.31	0.2756	2.56	0.0372	0.35	0.1622	1.53	0.5992	5.61	0.0699	0.65
	Akanogohan	4	13.2521	10.7147	80.85	0.6615	4.99	0.2719	2.05	0.0290	0.21	0.1657	1.25	0.6144	4.63	0.0398	0.30
		5	12.2558	9.5816	78.18	0.6273	5.11	0.2749	2.24	0.0270	0.22	0.1627	1.32	0.5961	4.86	0.0513	0.42
		Moy-Aver	12.7540	10.1482	79.52	0.6444	5.05	0.2734	2.15	0.0280	0.22	0.1642	1.34	0.6053	4.75	0.0456	0.36
	Riz cuit Boiled rice	6	13.1241	10.6901	81.45	0.7155	5.99	0.2539	1.93	0.0324	0.24	0.1555	1.17	0.6022	4.58	0.0251	0.24
		7	11.6516	9.7342	81.54	0.6729	5.78	0.2446	2.09	0.0304	0.26	0.1330	1.14	0.6022	5.16	0.0317	0.27
		Moy-Aver	12.3879	10.2122	82.50	0.6742	5.89	0.2493	2.01	0.0314	0.25	0.1443	1.16	0.6022	4.87	0.0284	0.26
Imai	Riz cuit Boiled rice	2	12.1638	9.8499	80.97	0.5136	4.22	0.2392	1.96	0.0263	0.21	0.1939	1.59	0.5236	4.30	0.0140	0.11
		3	12.6759	10.2333	80.73	0.4980	3.91	0.2392	1.89	0.0331	0.26	0.1896	1.49	0.5846	4.61	0.0175	0.13
		Moy-Aver	12.4199	10.0416	80.85	0.5058	4.12	0.2392	1.93	0.0302	0.24	0.1918	1.54	0.5541	4.46	0.0158	0.12
	Akanogohan	4	12.4198	9.4866	82.38	0.6045	4.86	0.2232	1.79	0.0270	0.21	0.1943	1.56	0.5326	4.28	0.0149	0.12
		5	12.3558	10.0707	81.50	0.6045	4.89	0.2262	1.83	0.0284	0.23	0.1859	1.50	0.5018	4.06	0.0129	0.10
		Moy-Aver	12.3878	9.7787	81.94	0.6045	4.88	0.2247	1.81	0.0277	0.22	0.1901	1.53	0.5172	4.17	0.0139	0.11

Sujets Subjects	Période Period	Date Nov.	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	(%)	Azote de NH^3 Ammonia N. (g)	(%)	Azote de l'acide urique Uric acid N. (g)	(%)	Azote des bases puriques Purin base N. (g)	(%)	Azote des acides aminés Amino acid N. (g)	(%)	Azote de la créatinine Creatinin N. (g)	(%)	Azote de la créatine Creatin N. (g)	(%)
Imai	Riz cuit Boiled rice	6	13.3521	10.8383	81.17	0.6273	4.69	0.2339	1.75	0.0270	0.20	0.1728	1.37	0.5103	3.82	0.0088	0.06
		7	13.5082	10.3711	76.77	0.6957	5.15	0.1930	1.42	0.0279	0.20	0.1544	1.14	0.5376	3.98	0.0098	0.07
		Moy-Aver	13.4302	10.6047	78.97	0.6615	4.92	0.2135	1.59	0.0275	0.20	0.1636	1.21	0.5205	3.90	0.0093	0.07
Shimizu	Riz cuit Boiled rice	2	12.2232	9.9967	81.78	0.6957	5.69	0.1718	1.41	0.0209	0.17	0.1769	1.44	0.4544	3.71	0.0088	0.07
		3	13.4442	10.9515	81.46	0.4904	3.64	0.2262	1.68	0.0344	0.25	0.1724	1.28	0.5326	3.96	0.0094	0.07
		Moy-Aver	12.8337	10.4741	81.62	0.5931	4.67	0.1990	1.55	0.0277	0.21	0.1747	1.36	0.4935	3.84	0.0091	0.07
	Akanogohan	4	12.2764	11.4589	80.26	0.5956	4.87	0.2871	2.01	0.0331	0.23	0.2000	1.40	0.5103	3.57	0.0133	0.09
		5	14.2124	11.8746	83.55	0.7847	5.52	0.2262	1.59	0.5311	0.21	0.1917	1.35	0.5474	3.85	0.0101	0.07
		Moy-Aver	14.2444	11.6668	81.91	0.7402	5.20	0.2567	1.80	0.0321	0.22	0.1959	1.38	0.5289	3.71	0.0117	0.08
	Riz cuit Boiled rice	6	13.1881	10.9997	83.40	0.6957	5.27	0.2305	1.74	0.0304	0.23	0.1670	1.26	0.5018	3.80	0.0085	0.06
		7	14.7246	12.0524	83.21	0.9585	6.51	0.2171	1.47	0.0317	0.21	0.1487	1.01	0.5846	3.97	0.0175	0.12
		Moy-Aver	13.9564	11.5261	83.31	0.8271	5.94	0.2238	1.61	0.0341	0.22	0.1579	1.14	0.5432	3.89	0.0130	0.09
Tanaka	Riz cuit Boiled rice	2	11.6516	9.2751	79.60	0.5816	4.99	0.1718	1.47	0.0230	0.19	0.1883	1.61	0.4741	4.06	0.0076	0.06
		3	13.1241	10.4238	79.42	0.4464	3.40	0.2262	1.72	0.0311	0.24	0.1651	1 26	0.5326	4.06	0.0149	0.11
		Moy-Aver	12.3879	9.8495	79.51	0.5140	4.20	0.1990	1.60	0.0271	0.22	0.1767	1.44	0.5034	4.06	0.0113	0.09
	Akanogohan	4	13.9563	10.7758	77.21	0.6618	4.74	0.2871	2.06	0.0223	0.16	0.1714	1.23	0.5018	3.60	0.0129	0.09
		5	12.1638	9.4662	77.82	0.7071	5.81	0.2262	1.85	0.0263	0.21	0.1743	1.43	0.4934	4.05	0.0084	0.07
		Moy-Aver	13.0601	10.1210	77.52	0.6845	5.28	0.2567	1.96	0.0243	0.19	0.1729	1.33	0.4976	3.83	0.0107	0.08
	Riz cuit Boiled rice	6	11.5876	9.5552	82.46	0.7071	6.10	0.2305	1.99	0.0243	0.21	0.1613	1.39	0.4934	4.25	0.0084	0.07
		7	12.5479	10.2804	81.93	0.8436	6.72	0.2141	1.71	0.0236	0.19	0.1602	1.28	0.5018	3.99	0.0085	0.07
		Moy-Aver	12.0678	9.9178	82.20	0.7754	6.41	0.2223	1.85	0.0240	0.20	0.1608	1.34	0.4976	4.12	0.0085	0.07

Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Higuchi			Tanaka		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz cuit Boiled rice	Novem. 2	1.4669	1.2054	15.9	1.8050	1.0468	18.4
	3	1.9806	1.2642	21.9	2.1095	1.4112	21.1
	Moyenne — Aver.	1.7238	1.2348	18.9	1.9537	1.2290	19.8
Akanogohan	4	1.9868	1.3377	20.3	2.0254	1.6170	25.2
	5	1.9197	1.4406	22.8	1.9593	1.5288	22.9
	Moyenne — Aver.	1.9533	1.3892	21.6	1.9924	1.5729	24.1
Riz cuit Boiled rice	6	1.8832	1.5141	23.4	2.0176	1.4847	25.1
	7	2.1549	1.3965	18.9	1.8311	1.3965	19.3
	Moyenne — Aver.	2.0191	1.4553	21.2	1.9244	1.4406	22.2

Période Period	Date	Imai			Shimizu			Tanaka		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz cuit Boiled rice	Novem. 2	1.9924	1.1760	16.7	2.0076	1.0290	19.1	1.9013	1.1907	19.9
	3	1.8257	1.4700	24.3	2.0844	1.1907	20.5	1.9847	1.4994	20.4
	Moyenne — Aver.	1.9091	1.3230	20.5	2.0460	1.1099	19.8	1.9430	1.3451	20.2
Akanogohan	4	1.8153	1.4700	23.5	2.1493	1.6317	22.3	2.0481	1.4994	23.3
	5	1.8921	1.3718	26.2	2.2364	1.5141	26.2	2.0419	1.3083	25.5
	Moyenne — Aver.	1.8537	1.4209	24.9	2.1929	1.5729	24.3	2.0450	1.4039	24.4
Riz cuit Boiled rice	6	2.0955	1.5288	20.9	1.9813	1.4994	18.4	1.8112	1.4406	20.7
	7	2.0803	1.4653	21.2	2.1616	1.6611	21.3	1.9790	1.4653	26.1
	Moyenne — Aver.	2.0879	1.4971	21.1	2.0715	1.5803	19.9	1.8951	1.4530	23.4

Sujet / Subject	Période / Period	Absorption d'azote Moyenne journalière — N. intake Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Azote trouvé dans l'urine Moyenne journalière — N. in urine Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Azote trouvé dans les selles Moyenne journalière — N. in fæces Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière — Absorption Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	Pourcentage d'absorption % of absorption
Higuchi . .	Riz cuit . . . . Boiled rice . . .	13.8176	86.3599	11.5158	83.34	2.5808	18.67	— 0.2790	11.2368	70.2300	287.943	81.33
	Akanogohan . . Riz cuit	13.7408	85.8799	12.1123	88.15	1.2843	9.35	+ 0.3442	12.4565	77.8531	319.198	90.65
	Boiled rice . . .	13.8176	86.3599	12.8601	93.07	2.5714	18.61	— 1.6139	11.2462	70.2888	288.184	81.39
Tanaka . .	*Idem*	14.2538	89.0862	11.1439	78.18	2.9313	20.56	+ 0.1786	11.3225	70.7656	290.139	79.44
		14.3855	89.9093	12.7540	88.66	2.7028	18.69	— 1.0713	11.6827	73.0169	299.369	81.31
		13.8176	86.3599	12.3879	89.65	2.7633	19.99	— 1.3336	11.0543	69.0894	283.267	80.01
Imai . . .	*Idem*	13.8176	86.3599	12.4199	89.88	2.1692	15.69	— 0.7715	11.6484	72.8025	298.490	84.31
		13.7408	85.8799	12.3878	90.15	2.2526	16.42	— 0.8996	11.4882	71.8013	294.385	83.58
		13.8176	86.3599	13.4302	97.19	2.5764	18.65	— 2.1908	11.2412	70.2575	288.056	81.35
Shimizu . .	*Idem*	14.4719	90.4493	12.8337	88.68	2.2147	15.45	— 0.5765	12.2572	76.6075	314.091	84.55
		14.8153	92.5955	14.2444	96.14	2.1881	14.77	— 1.6172	12.6272	78.9200	323.572	85.23
		15.1262	94.5387	13.9564	92.26	2.2935	15.16	— 1.1237	12.8327	80.2044	328 838	84.84
T. Tanaka .	*Idem*	12.9452	80.9073	12.3879	95.69	2.3885	18.45	— 1.8312	10.5567	65.9794	270.516	81.55
		13.0961	81.8505	13.0601	99.72	2.2500	17.18	— 2.2140	10.8461	67.7881	277.931	82.82
		12.7271	79.5443	12.0678	94.82	2.2989	18.06	— 1.6396	10.4282	65.1763	267.223	81.94

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fœces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Higuchi .	Riz cuit . . . Boiled rice . .	494.26	1.1919	0.24	493.07	2021.587	99.76
	Akanogohan .	416.02	0.6812	0.16	415.34	1702.894	99.84
	Riz cuit . . . Boiled rice . .	494.26	1.3026	0.26	492.96	2021.136	99.74
Tanaka .	*Idem*	528.41	1.8106	0.34	526.60	2159.060	99.66
		457.47	1.1939	0.26	456.28	1870.748	99.74
		494.26	1.8768	0.38	492.38	2018.758	99.62
Imai . .	*Idem*	494.26	1.4214	0.29	492.84	2020.644	99.71
		416.02	1.3715	0.32	414.65	1700.065	99.68
		494.26	1.8116	0.37	492.45	2019.045	99.63
Shimizu .	*Idem*	545.49	1.6799	0.31	543.81	2229.621	99.69
		485.15	1.6604	0.34	483.49	1982.309	99.66
		596.71	1.8136	0.30	594.90	2439.090	99.70
T. Tanaka	*Idem*	425.96	1.6163	0.38	424.34	1739.794	99.62
		374.58	1.6012	0.42	372.98	1529.218	99.58
		408.89	1.8700	0.45	407.02	1668.782	99.55

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Higuchi .	Riz cuit . . . Boiled rice . .	19.95	1.7367	8.71	18.21	169.353	91.29
	Akanogohan .	19.65	0.7769	3.95	18.87	175.491	96.05
	Riz cuit . . . Boiled rice . .	19.95	1.8027	9.04	18.15	168.795	90.96
Tanaka	*Idem*	20.25	1.9249	9.51	18.33	170.469	90.49
		19.73	1.7760	9.00	17.95	166.935	91.00
		19.95	1.7370	8.71	18.21	169.353	91.29
Imai . .	*Idem*	19.95	2.1831	10.94	17.77	165.261	89.06
		19.65	1.7649	8.98	17.89	166.377	91.02
		19.95	1.8925	9.48	18.06	167.958	90.52
Shimizu .	*Idem*	20.40	2.0790	10.14	18.32	170.376	89.86
		19.98	1.7417	8.72	18.24	169.632	91.28
		20.85	2.0539	9.85	18.80	174.840	90.15
T. Tanaka	*Idem*	19.35	1.7672	9.13	17.58	163.494	90.87
		18.98	1.5892	8.37	17.39	161.727	91.63
		19.20	1.7720	9.23	17.43	162.099	90.77

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Higuchi .	Riz cuit.	25.95	3.5257	13.58	86.42
	Boiled rice				
	Akanogohan	28.11	1.6634	5.92	94.08
	Riz cuit.	25.95	3.5577	13.71	86.29
	Boiled rice				
Tanaka .	*Idem*	26.10	4.2372	17.00	83.00
		28.61	3.4626	13.11	86.89
		25.95	3.8723	14.92	85.08
Imai . .	*Idem*	25.95	2.7934	10.76	89.24
		28.11	2.9608	10.53	89.47
		25.95	3.8083	14.68	85.32
Shimizu. .	*Idem*	26.18	2.4970	9.53	90.47
		28.94	2.6048	9.00	91.00
		26.40	2.8078	10.63	89.37
T. Tanaka.	*Idem*	25.65	2.5356	9.88	90.12
		27.62	2.5557	9.25	90.75
		25.58	2.5960	10.11	89.89

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Caloric utilisation		% de la quantité de calories absorbées % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Higuchi .	Riz cuit . . . . Boiled rice . . .	2566.077	48.89	2478.883	47.23	96.60
	Akanogohan . .	2237.745	42.66	2197.583	41.89	98.19
	Riz cuit . . . . Boiled rice . . .	2566.077	48.90	2478.115	47.24	96.60
Tanaka .	*Idem*	2720.059	51.51	2619.698	49.61	96.31
		2427.744	46.02	2337.052	44.30	96.26
		2566.077	49.08	2471.378	47.27	96.31
Imai . . .	*Idem*	2566.077	48.74	2484.395	47.19	96.81
		2237.745	42.78	2160.827	41.32	96.59
		2566.077	49.63	2475.059	47.87	96.45
Shimizu .	*Idem*	2797.071	49.17	2714.088	47.71	97.03
		2554.670	44.94	2475.513	43.54	96.90
		3028.025	53.28	2942.768	51.78	97.18
T. Tanaka	*Idem*	2258.111	46.27	2173.804	44.54	96.26
		2047.879	42.01	1968.876	40.38	96.12
		2181.141	44.97	2098.104	43.26	96.19

Percentage of the Digestibility and Utilisation of Each Constituent.

Période Period	Azote total Total nitrogen %	Hydrates de carbone comme le glycose Carbo-hydrate as glucose %	Graisse brute Crude fat %	Cendres brutes Crude ash %	Calories %
Riz cuit — Boiled rice	82.236	99.688	90.314	87.850	96.602
Akanogohan	84.718	99.700	92.196	90.438	96.812
Riz cuit — Boiled rice	81.906	99.648	90.738	87.190	96.546

Conclusion.

1. The digestibility and utilisation of each constituent were slightly better during the " Akanogohan " period (except in the case of the carbohydrate utilisation). There was not much difference in the amount of energy supplied.

2. The ratio of total urine nitrogen to nitrogen intake could not be compared in the two periods, because the nitrogen balance was frequently negative; but the individual nitrogenous compounds were usually present in physiological proportions; the percentage of uric acid nitrogen in the urine decreased slightly during the " Akanogohan " period.

3. The amounts of boiled rice and of " Akanogohan " eaten were almost the same during the two periods. The output of fæces (wet and air-dried) was almost the same in the two periods.

Experiment VI (*b*).

Comparison of the Digestibility and Utilisation of " Akanogohan " and Ordinary Boiled Rice.

The Akanogohan was prepared by the subjects themselves. Red beans were boiled with 500 cc. of water for one hour during the evening preceding the experiment in an earthenware cooker. Each morning of the " Akanogohan " period a definite quantity of polished rice was added to the boiled red beans (red beans 1: polished rice 8) and the mixture was again cooked. This " Akanogohan " was divided into three portions and made three meals for each subject.

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date Sept.	Azote total Total N. (g)	Azote de l'urée Urea N.		Azote de NH^3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
				(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Shimizu	Riz cuit Boiled rice	16	9.4612	6.5069	68.77	0.5237	5.54	0.1802	1.90	0.0144	0.15	0.2092	2.21	0.5059	5.34	0.0087	0.09
		17	9.8708	7.6172	77.17	0.4549	4.61	0.1698	1.72	0.0352	0.36	0.1720	1.74	0.5474	5.55	0.0101	0.12
		Moy-Aver	9.6660	7.0621	72.97	0.4888	5.08	0.1750	1.81	0.0248	0.20	0.1906	1.98	0.5267	5.44	0.0094	0.15
	Akanogohan	18	8.3267	6.3412	76.16	0.5106	6.12	0.2325	2.79	0.0228	0.27	0.1825	2.19	0.5474	6.57	0.0101	0.12
		19	9.9259	7.8379	78.96	0.4135	4.17	0.1711	1.72	0.0310	0.31	0.2101	2.12	0.5576	5.62	0.0159	0.16
		Moy-Aver	9.1263	7.0896	77.56	0.4618	5.14	0.2018	2.26	0.0269	0.29	0.1963	2.15	0.5525	6.10	0.0130	0.14
	Riz cuit Boiled rice	20	10.0996	7.8728	77.95	0.4549	4.50	0.1730	1.71	0.0189	0.18	0.1977	1.96	0.5410	5.36	0.0132	0.13
		21	9.7329	7.0343	72.28	0.4725	4.85	0.2052	2.11	0.0214	0.22	0.2044	2.10	0.5474	5.62	0.0153	1.16
		Moy-Aver	9.9162	7.4536	74.66	0.4637	4.68	0.1891	1.91	0.0202	0.20	0.2011	2.03	0.5442	5.49	0.0148	0.14
Imai	Riz cuit Boiled rice	16	9.8983	7.2957	72.69	0.5100	5.15	0.1709	1.73	0.0172	0.17	0.1729	1.75	0.4934	4.98	0.0126	0.12
		17	9.1815	7.2238	78.68	0.6065	6.61	0.1643	1.79	0.0172	0.19	0.1710	1.86	0.5376	5.84	0.0098	0.10
		Moy-Aver	9.5399	7.2418	75.69	0.5583	5.88	0.1676	1.76	0.0172	0.18	0.1719	1.80	0.5155	5.41	0.0117	0.11
	Akanogohan	18	10.1177	8.2716	81.76	0.5642	5.58	0.2386	2.36	0.0296	0.29	0.1931	1.91	0.5236	5.18	0.0090	0.09
		19	9.3193	7.7202	82.85	0.4273	4.59	0.1958	2.10	0.0228	0.24	0.1998	2.14	0.5236	5.62	0.0140	0.15
		Moy-Aver	9.7185	7.9959	81.82	0.4958	5.08	0.2172	2.23	0.0262	0.27	0.1965	2.03	0.5236	5.40	0.0115	0.12
	Riz cuit Boiled rice	20	9.9851	7.5547	75.66	0.5237	5.24	0.2141	2.15	0.0203	0.20	0.1921	1.92	0.5149	5.16	0.0089	0.09
		21	9.4021	7.8304	83.26	0.4962	5.28	0.2178	2.32	0.0186	0.20	0.1864	1.99	0.5018	5.34	0.0129	0.14
		Moy-Aver	9.6936	7.6926	79.47	0.5099	5.26	0.2159	2.23	0.0195	0.20	0.1893	1.96	0.5039	5.25	0.0109	0.11

(Continuation.)

Sujets Subjects	Période Period	Date Sept.	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	(%)	Azote de NH^3 Ammonia N. (g)	(%)	Azote de l'acide urique Uric acid N. (g)	(%)	Azote des bases puriques Purin base N. (g)	(%)	Azote des acides aminés Amino acid N. (g)	(%)	Azote de la créatinine Creatinin N. (g)	(%)	Azote de la créatine Creatin N. (g)	(%)
Nishibori	Riz cuit Boiled rice	16	9.4296	7.1825	76.28	0.5376	5.70	0.1585	1.68	0.0228	0.24	0.1991	2.11	0.4632	4.93	0.0072	0.08
		17	10.1465	7.9407	78.26	0.5927	5.84	0.1782	1.76	0.0255	0.25	0.2059	2.03	0.5018	4.95	0.0129	0.13
		Moy-Aver	9.7881	7.5616	77.27	0.5652	5.77	0.1684	1.72	0.0241	0.25	0.2025	2.07	0.4825	4.94	0.0097	0.10
	Akanogohan	18	11.9938	9.5812	79.97	0.5514	4.60	0.2141	1.79	0.0283	0.24	0.2048	1.70	0.5236	4.37	0.0090	0.08
		19	10.7807	8.3404	77.37	0.6065	5.62	0.2213	2.05	0.0159	0.15	0.1707	1.58	0.5236	4.86	0.0140	0.13
		Moy-Aver	11.3872	8.9608	78.67	0.5789	5.11	0.2177	1.97	0.0171	0.19	0.1878	1.69	0.5236	4.61	0.0115	0.10
	Riz cuit Boiled rice	20	10.3946	7.6098	73.21	0.5100	4.91	0.1730	1.66	0.0145	0.14	0.1887	1.81	0.4704	4.53	0.0113	0.11
		21	10.5601	8.1061	76.67	0.5376	5.09	0.2202	2.09	0.0207	0.20	0.1944	1.84	0.4817	4.56	0.0078	0.07
		Moy-Aver	10.4773	7.8579	74.94	0.5218	5.00	0.1966	1.82	0.0176	0.17	0.1916	1.83	0.4762	4.54	0.0096	0.09
Hirata	Riz cuit Boiled rice	16	10.5601	7.5575	71.57	0.5652	5.35	0.1822	1.73	0.0255	0.24	0.1725	1.63	0.4632	4.39	0.0109	0.10
		17	10.0638	7.5547	75.06	0.6203	6.16	0.1876	1.86	0.0207	0.21	0.1612	1.60	0.4817	4.79	0.0117	0.12
		Moy-Aver	10.3119	7.5561	73.32	0.5928	5.76	0.1849	1.79	0.0231	0.22	0.1669	1.62	0.4730	4.59	0.0113	0.11
	Akanogohan	18	10.4498	7.9447	76.03	0.5514	5.28	0.1995	1.91	0.0199	0.19	0.1768	1.69	0.5018	4.80	0.0129	0.12
		19	12.8210	10.2114	79.65	0.5927	4.62	0.1444	1.12	0.0241	0.19	0.2168	1.69	0.4934	3.85	0.0126	0.10
		Moy-Aver	11.6354	9.0781	77.84	0.5721	4.95	0.1719	1.26	0.0220	0.19	0.1968	1.69	0.4976	4.33	0.0128	0.11
	Riz cuit Boiled rice	20	9.4612	7.6781	81.16	0.5376	5.68	0.1703	1.80	0.0117	0.12	0.1869	1.98	0.4704	4.96	0.0113	0.12
		21	9.2366	7.2653	78.66	0.4135	4.48	0.1802	1.95	0.0203	0.22	0.1699	1.84	0.4955	5.36	0.0112	0.12
		Moy-Aver	9.3489	7.4721	79.91	0.4756	5.08	0.1753	1.87	0.0160	0.17	0.1874	1.91	0.4830	5.16	0.0113	0.12

Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Shimizu			Imai		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz cuit Boiled rice	Sept. 16	1.4543	1.4202	18.2	1.3842	1.1716	19.0
	17	1.5655	1.5216	22.8	1.3088	1.1209	21.0
	Moyenne –Aver.	1.5099	1.4709	20.5	1.3465	1.1469	20.0
Akanogohan	18	1.3890	1.8665	21.3	1.4365	1.6535	23.7
	19	1.5943	1.6484	21.7	1.4763	1.2376	20.9
	Moyenne –Aver.	1.4917	1.7574	21.5	1.4564	1.4445	22.3
Riz cuit Boiled rice	20	1.5026	1.8077	22.2	1.3815	1.6940	21.2
	21	1.6443	1.3492	23.6	1.3494	1.4495	23.1
	Moyenne –Aver.	1.5735	1.5784	22.9	1.3655	1.5717	22.2

Période Period	Date	Nishibori			Hirata		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz cuit Boiled rice	Sept. 16	1.4481	1.4100	16.6	1.5840	1.2680	22.5
	17	1.7040	1.5013	19.8	1.5723	1.4363	23.1
	Moyenne –Aver.	1.5761	1.4556	18.2	1.5782	1.3521	22.8
Akanogohan	18	1.8584	1.8593	23.4	1.6478	1.3694	24.0
	19	1.8921	1.6636	21.2	2.1485	1.3621	20.9
	Moyenne –Aver.	1.8753	1.7614	22.3	1.8982	1.3657	22.5
Riz cuit Boiled rice	20	1.7967	1.5774	22.8	1.4200	1.2883	20.9
	21	1.6263	1.2071	20.4	1.4145	1.5657	21.7
	Moyenne –Aver.	1.7115	1.3922	21.6	1.4173	1.4270	21.3

Sujets Subject	Période Period	Absorption d'azote Moyenne journalière N. intake Average per day		Azote trouvé dans l'urine Moyenne journalière N. in urine Average per day		Azote trouvé dans les selles Moyenne journalière N. in fæces Average per day		Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière Absorption Average per day			Pourcentage d'absorption % of absorption
		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	
Shimizu . .	Riz cuit . . . . Boiled rice . . .	14.3420	89.6408	9.6660	67.32	1.6082	11.21	+ 2.9678	12.7338	79.5863	326.304	88.79
	Akanogohan . .	15.0865	94.2969	9.1263	60.49	3.9180	25.97	+ 1.0422	11.1685	69.8031	286.193	74.03
	Riz cuit . . . . Boiled rice . . .	14.5692	91.0638	9.9162	68.06	2.4229	16.64	+ 2.2301	12.1463	75.9144	311.249	83.36
Imai . . .	*Idem*	14.7964	92.4838	9.5399	64.47	2.4898	16.83	+ 2.7667	12.3067	76.9169	315.359	83.17
		15.0865	94.2969	9.7185	64.41	3.1246	20.71	+ 2.2434	11.9619	74.7619	306.524	79.29
		14.5692	91.0638	9.6936	66.53	2.2637	15.54	+ 2.6119	12.3055	76.9094	315.329	84.46
Nishibori .	*Idem*	13.6594	85.3838	9.7881	71.65	2.4009	17.58	+ 1.4704	11.2585	70.3656	288.499	82.42
		14.6074	91.2963	11.3872	77.95	2.6676	18.26	+ 0.5426	11.9398	74.6238	305.958	81.74
		14.1148	88.2288	10.4773	74.23	2.3850	16.90	+ 1.2525	11.7298	73.3113	300.576	83.10
Hirata. . .	*Idem*	13.6594	85.3838	10.3119	75.42	2.3198	16.98	+ 1.0277	11.3396	70.8725	290.577	83.02
		14.1162	88.2326	11.6354	83.13	2.6276	18.61	— 0.1468	11.4886	71.8038	294.396	81.39
		13.6594	85.3838	9.3489	68.44	1.6991	12.44	+ 2.6114	11.9603	74.7519	306.483	87.56

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Shimizu .	Riz cuit . . . Boiled rice . .	518.720	1.5170	0.29	517.203	2120.532	99.71
	Akanogohan .	514.552	3.5260	0.69	511.026	2095.207	99.31
	Riz cuit . . . Boiled rice . .	530.610	1.8352	0.35	528.775	2167.978	99.65
Imai . .	*Idem*	552.500	2.3630	0.43	550.137	2255.562	99.57
		514.552	2.5621	0.50	511.990	2099.159	99.50
		530.610	2.1828	0.41	528.427	2166.541	99.59
Nishibori.	*Idem*	473.050	1.9321	0.41	471.918	1934.864	99.59
		482.756	1.8729	0.39	480.883	1971.620	99.61
		506.830	0.8431	0.17	505.987	2074.547	99.83
Hirata .	*Idem*	473.050	1.7505	0.37	471.300	1932.330	99.63
		450.960	2.7040	0.60	448.256	1837.850	99.40
		473.050	1.2192	0.26	471.831	1934.507	99.74

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Shimizu .	Riz cuit . . . Boiled rice . .	17.123	1.0969	6.41	16.026	149.042	93.59
	Akanogohan .	18.235	2.6082	14.30	15.627	145.331	85.70
	Riz cuit . . . Boiled rice . .	17.262	1.1279	6.53	16.134	150.046	93.47
Imai . .	*Idem*	17.400	1.4406	8.28	15.959	148.419	91.72
		18.235	2.5492	13.98	15.686	145.880	86.02
		17.262	1.9542	11.32	15.308	142.364	88.68
Nishibori.	*Idem*	16.708	1.8973	11.36	14.811	137.742	88.64
		17.890	1.3329	7.45	16.557	153.980	92.55
		16.985	1.4627	8.61	15.522	144.355	91.39
Hirata .	*Idem*	16.708	2.5826	15.46	14.125	131.363	84.54
		17.545	2.8510	16.25	14.694	136.654	83.75
		16.708	1.5277	9.14	15.180	141.174	90.86

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Shimizu. .	Riz cuit.	27.442	1.8056	6.58	93.42
	Boiled rice				
	Akanogohan	28.358	4.2484	14.98	85.02
	Riz cuit.	27.538	2.6285	9.94	90.06
	Boiled rice				
Imai . .	*Idem*	27.633	2.5997	9.41	90.59
		28.358	3.0451	10.74	89.26
		27.538	2.8925	10.50	89.50
Nishibori .	*Idem*	27.156	2.7916	10.28	89.72
		28.109	2.5710	9.15	90.85
		27.347	2.8910	10.57	89.43
Hirata . .	*Item*	27.156	2.6460	9.74	90.26
		27.861	3.5840	12.86	87.14
		27.156	2.7388	10.09	89.91

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Caloric utilisation		% de la quantité de calories absorbée % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Shimizu .	Riz cuit	2653.524	46.84	2595.878	45.82	97.82
	Boiled rice . . .					
	Akanogohan . .	2665.866	47.02	2526.731	44.55	94.75
	Riz cuit	2709.399	47.74	2629.273	46.33	97.05
	Boiled rice . . .					
Imai . .	*Idem*	2806.254	53.25	2719.340	51.60	96.90
		2665.866	50.25	2551.563	48.09	95.70
		2709.399	50.93	2624.234	49.32	96.85
Nishibori	*Idem*	2444.963	49.79	2361.105	48.09	96.58
		2519.992	50.96	2431.558	49.17	96.48
		2597.681	52.48	2519.478	50.90	96.98
Hirata . .	*Idem*	2444.963	51.36	2354.270	49.46	96.30
		2373.858	49.87	2268.900	47.66	95.57
		2444.963	50.93	2382.164	49.64	97.46

Digestibility and Utilisation of Each Constituent.

Période Period	Azote total Total nitrogen %	Hydrates de carbone comme le glycose Carbo-hydrate as glucose %	Graisse brute Crude fat %	Cendres brutes Crude ash %	Calories %
Riz cuit — Boiled rice	84.350	99.625	89.623	90.997	96.900
Akanogohan	79.112	99.455	87.005	88.067	95.625
Riz cuit — Boiled rice	84.620	99.702	91.100	89.722	97.082

Conclusion.

1. The digestibility and utilisation of each constituent were better when boiled rice was used than when " Akanogohan " was used. except in one case. The amount of energy supplied was greater during the boiled-rice period than during the " Akanogohan " period.

2. There was not much variation in the percentage of total nitrogen in the urine during the two periods and the individual nitrogenous compounds in the urine remained almost constant, except that the ratio of urea nitrogen to total urine nitrogen was slightly increased during the " Akanogohan " period.

3. The amount eaten (reckoned as uncooked rice) was the same in each period, but the output of fæces was greater when " Akanogohan " was used.

In the previous experiment, the digestibility of " Akanogohan " cooked only with the juice of red beans was slightly better than that of ordinary boiled rice, but in this experiment the digestibility of " Akanogohan " cooked with whole red beans was poorer than that of ordinary boiled rice.

Experiment VII.

Comparison of the Digestibility and Utilisation of " Okowa " with Ordinary Boiled Rice.

For the preparation of " Okowa " 7 " go " of glutinous rice were mixed with 3 " go " of non-glutinous rice. The mixture was then washed and soaked in 2,000 cc. of water for 24 hours. The water was removed the next morning, and the rice was steamed in boiling water (3,500 cc.) for 45 minutes.

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	(%)	Azote de NH^3 Ammonia N. (g)	(%)	Azote de l'acide urique Uric acid N. (g)	(%)	Azote des bases puriques Purin base N. (g)	(%)	Azote des acides aminés Amino acid N. (g)	(%)	Azote de la créatinine Creatinin N. (g)	(%)	Azote de la créatine Creatin N. (g)	(%)
Kayano	Riz cuit Boiled rice	Nov. 28	11.2682	8.0970	71.86	0.5136	4.56	0.2446	2.17	0.0277	0.25	0.1845	1.64	0.5376	4.77	0.0098	0.09
		29	11.9084	9.0698	76.25	0.7250	6.09	0.2294	1.93	0.0270	0.23	0.1551	1.31	0.5474	4.59	0.0101	0.09
		Moy-Aver	11.5883	8.5834	74.06	0.6193	5.33	0.2370	2.05	0.0274	0.24	0.1698	1.48	0.5425	4.68	0.0100	0.09
	Okowa	30	10.7553	8.1499	75.77	0.5018	4.67	0.2567	2.39	0.0270	0.25	0.2167	2.01	0.5282	4.91	0.0095	0.09
		Dec. 1	11.5876	8.9323	77.09	0.6273	5.41	0.2243	1.94	0.0209	0.18	0.1758	1.52	0.5326	4.59	0.0149	0.13
		Moy-Aver	11.1715	8.5411	76.43	0.5646	5.04	0.2305	2.17	0.0240	0.22	0.1963	1.77	0.5304	4.75	0.0122	0.11
	Riz cuit Boiled rice	2	11.9717	9.2349	77.14	0.6295	5.26	0.2446	2.04	0.0277	0.23	0.1807	1.51	0.5149	4.30	0.0089	0.07
		3	12.7399	9.5621	75.05	0.5702	4.48	0.3123	2.45	0.0250	0.19	0.1848	1.45	0.5282	4.15	0.0095	0.08
		Moy-Aver	12.3558	9.3985	76.10	0.5999	4.87	0.2782	2.25	0.0264	0.21	0.1828	1.48	0.5216	4.23	0.0092	0.08
Sakaguchi	Riz cuit Boiled rice	Nov. 28	11.2035	8.7415	78.02	0.5702	5.09	0.2539	2.27	0.0182	0.16	0.1729	1.54	0.5474	4.88	0.0101	0.09
		29	10.8834	8.3685	76.89	0.7071	6.49	0.2305	2.12	0.0196	0.18	0.1729	1.58	0.5376	4.94	0.0098	0.09
		Moy-Aver	11.0435	8.5550	77.46	0.6387	5.79	0.2422	2.20	0.0189	0.17	0.1729	1.56	0.5425	4.91	0.0100	0.09
	Okowa	30	11.0754	8.2868	74.82	0.7702	6.95	0.3113	2.81	0.0236	0.21	0.1426	1.29	0.5474	4.94	0.0101	0.09
		Dec. 1	10.8193	8.8319	81.63	0.6045	5.59	0.2689	2.48	0.0230	0.21	0.1699	1.57	0.5018	4.64	0.0129	0.12
		Moy-Aver	10.9374	8.5594	78.23	0.6874	6.27	0.2901	2.65	0.0233	0.21	0.1563	1.43	0.5246	4.79	0.0115	0.11
	Riz cuit Boiled rice	2	10.6913	7.9532	74.39	0.6501	6.08	0.2689	2.51	0.0224	0.21	0.1574	1.47	0.5149	4.89	0.0135	0.12
		3	11.5236	8.2660	71.73	0.7527	6.53	0.2505	2.17	0.0236	0.21	0.1617	1.40	0.5326	4.62	0.0101	0.09
		Moy-Aver	11.1075	8.1096	73.06	0.7014	6.31	0.2597	2.34	0.0230	0.21	0.1596	1.44	0.5238	4.76	0.0118	0.11
Imai	Riz cuit Boiled rice	Nov. 28	12.4288	9.8724	79.43	0.6273	5.05	0.2810	2.26	0.0270	0.22	0.1950	1.57	0.5282	4.25	0.0145	0.12
		29	13.3404	10.2183	81.99	0.6975	5.65	0.2359	1.91	0.0250	0.20	0.1902	1.54	0.5149	4.17	0.0135	0.11
		Moy-Aver	12.8846	10.0454	80.71	0.6624	5.35	0.2585	2.09	0.0260	0.21	0.1926	1.56	0.5216	4.21	0.0140	0.12
	Okowa	30	12.5722	10.1720	80.91	0.6045	4.81	0.2539	2.02	0.0257	0.20	0.1597	1.27	0.5018	3.99	0.0129	0.10
		Dec. 1	13.9806	11.1216	79.55	0.6956	4.97	0.2749	1.97	0.0277	0.19	0.1641	1.17	0.5576	3.99	0.0159	0.11
		Moy-Aver	13.2764	10.6468	80.23	0.6501	4.89	0.2644	2.00	0.0267	0.20	0.1619	1.22	0.5297	3.99	0.0144	0.11

(Continuation.)

Sujets Subjects	Période Period	Date	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	(%)	Azote de NH^3 Ammonia N. (g)	(%)	Azote de l'acide urique Uric acid N. (g)	(%)	Azote des bases puriques Purin base N. (g)	(%)	Azote des acides aminés Amino acid N. (g)	(%)	Azote de la créatinine Creatinin N. (g)	(%)	Azote de la créatine Creatin N. (g)	(%)
Imai	Riz cuit Boiled rice	Dec. 2	11.8680	9.6098	80.97	0.6501	5.47	0.2020	1.70	0.0250	0.21	0.1637	1.38	0.5018	4.23	0.0129	0.11
		3	12.4045	9.6230	77.58	0.7413	5.98	0.2596	2.09	0.0277	0.22	0.1675	1.35	0.5326	4.28	0.0149	0.12
		Moy-Aver	12.1363	9.6164	79.28	0.6957	5.73	0.2308	1.90	0.0264	0.22	0.1656	1.37	0.5172	4.26	0.0139	0.12
Shimizu	Riz cuit Boiled rice	Nov. 28	10.6913	7.9788	74.63	0.4464	4.18	0.2658	2.49	0.0290	0.27	0.1253	1.17	0.5018	4.69	0.0085	0.08
		29	9.9871	7.8939	79.05	0.6295	6.30	0.1718	1.72	0.0243	0.24	0.1611	1.61	0.4934	4.94	0.0126	0.13
		Moy-Aver	10.3392	7.9365	76.84	0.5380	5.24	0.2188	2.11	0.0267	0.26	0.1432	1.39	0.4976	4.82	0.0106	0.11
	Okowa	30	13.4442	10.8204	80.48	0.6501	4.83	0.2622	1.85	0.0270	0.20	0.1530	1.14	0.4895	3.64	0.0123	0.09
		Dec. 1	14.5965	10.3894	71.18	0.7071	4.84	0.2509	1.72	0.0284	0.19	0.1816	1.24	0.5236	3.59	0.0140	0.09
		Moy-Aver	14.0204	10.6049	75.83	0.6786	4.84	0.2566	1.79	0.0277	0.20	0.1673	1.19	0.5066	3.62	0.0132	0.09
	Riz cuit Boiled rice	2	13.6605	10.4303	76.35	0.8896	6.51	0.2262	1.66	0.0311	0.23	0.1574	1.15	0.5236	3.83	0.0090	0.07
		3	13.7246	11.0459	80.48	0.9369	6.82	0.3174	2.31	0.0304	0.22	0.1502	1.09	0.5282	3.85	0.0095	0.07
		Moy-Aver	13.6926	10.7381	78.42	0.9133	6.67	0.2718	1.99	0.0308	0.23	0.1538	1.12	0.5259	3.84	0.0093	0.07
Tanaka	Riz cuit Boiled rice	Nov. 28	9.8591	7.8452	79.57	0.5949	6.03	0.2385	2.42	0.0250	0.25	0.1491	1.51	0.4817	4.88	0.0078	0.08
		29	12.8040	10.7608	84.04	0.6939	5.42	0.2567	2.01	0.0311	0.24	0.1670	1.31	0.5018	3.92	0.0129	0.10
		Moy-Aver	11.3316	9.3030	81.81	0.6444	5.73	0.2476	2.22	0.0281	0.25	0.1581	1.41	0.4918	4.40	0.0104	0.09
	Okowa	30	11.5236	9.1570	79.48	0.6192	5.37	0.2234	1.94	0.0270	0.23	0.1483	1.29	0.5018	4.27	0.0085	0.07
		Dec. 1	11.0114	8.6650	78.69	0.6939	6.30	0.2116	1.92	0.0250	0.23	0.1578	1.43	0.4704	4.27	0.0113	0.10
		Moy-Aver	11.2675	8.9110	79.09	0.6566	5.84	0.2175	1.93	0.0260	0.23	0.1531	1.36	0.4861	4.27	0.0099	0.09
	Riz cuit Boiled rice	2	9.9231	7.7540	78.14	0.5194	5.23	0.1930	1.99	0.0270	0.27	0.1632	1.64	0.4856	4.89	0.0120	0.12
		3	11.6516	9.4925	81.47	0.6748	5.79	0.2294	1.97	0.0344	0.29	0.1551	1.33	0.5059	4.34	0.0087	0.07
		Moy-Aver	10.7874	8.6233	79.81	0.5971	5.51	0.2112	1.98	0.0307	0.28	0.1592	1.49	0.4958	4.62	0.0104	0.10

Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Kayano			Sakaguchi		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz cuit Boiled rice	Nov. 28	1.7537	1.5232	22.8	1.6736	1.3756	20.2
	29	1.7088	1.6565	24.0	1.6172	1.4280	21.7
	Moyenne –Aver.	1.7313	1.5899	23.4	1.6454	1.4018	21.0
Okowa	Nov. 30	1.5773	1.3138	25.1	1.7961	1.1424	23.1
	Dec. 1	1.7159	1.1424	25.5	1.5238	0.9520	24.1
	Moyenne –Aver.	1.6466	1.2281	25.3	1.6600	1.0472	23.6
Riz cuit Boiled rice	Dec. 2	1.7207	1.3519	24.1	1.6081	1.2186	26.3
	3	1.9778	1.5613	26.3	1.7669	1.4851	26.4
	Moyenne –Aver.	1.8493	1.4566	25.2	1.6875	1.3519	26.4

Période Period	Date	Imai			Shimizu			Tanaka		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Riz cuit Boiled rice	Nov. 28	1.9209	2.1134	19.8	1.5705	2.1325	18.6	1.5070	1.7326	19.9
	29	1.8654	1.7898	22.8	1.6056	1.6184	24.4	1.8832	2.0944	22.1
	Moyenne –Aver.	1.8932	1.9516	21.3	1.5881	1.8755	21.5	1.6951	1.9135	21.0
Okowa	Nov. 30	1.8679	1.7898	21.8	2.0903	1.9040	24.8	1.6802	1.6755	25.0
	Dec. 1	2.0826	1.3518	27.7	2.2782	1.4470	25.8	1.6307	1.4470	25.9
	Moyenne –Aver.	1.9753	1.5708	24.8	2.1843	1.6755	25.3	1.6555	1.5618	25.5
Riz cuit Boiled rice	Dec. 2	1.9202	1.7516	19.2	1.9664	1.8278	21.4	1.4932	1.5613	19.2
	3	1.7154	1.8849	25.2	2.1184	1.9992	28.9	1.6836	1.6946	26.5
	Moyenne –Aver.	1.8174	1.8183	22.2	2.0424	1.9135	25.2	1.5884	1.6280	22.9

Sujets Subject	Période Period	Absorption d'azote Moyenne journalière N. intake Average per day		Azote trouvé dans l'urine Moyenne journalière N. in urine Average per day		Azote trouvé dans les selles Moyenne journalière N. in fæces Average per day		Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière Absorption Average per day			Pourcentage d'absorption % of absorption
		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake		Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	
Kayano . .	Riz cuit	13.2536	82.8349	11.5883	87.43	1.8650	14.06	— 0.1997	11.3886	71.1788	291.833	85.94
	Boiled rice . . .											
	Okowa	13.8451	86.5318	11.1715	80.69	2.0573	14.86	+ 0.6163	11.7878	73.6738	302.063	85.14
	Riz cuit	13.2536	82.8349	12.3558	93.22	1.7943	13.54	— 0.8965	11.4593	71.6206	293.644	86.46
	Boiled rice . . .											
Sakaguchi .	*Idem*	13.6428	85.2647	11.0435	80.95	2.0317	14.89	— 0.5676	11.6111	72.5694	297.535	85.11
		15.0193	93.8705	10.9374	72.16	2.4057	16.02	+ 1.6762	12.6136	78.8350	323.224	83.98
		13.6428	85.2674	11.1075	81.42	2.1573	15.81	+ 0.3780	11.4855	71.7844	294.316	84.19
Imai . . .	*Idem*	13.2586	82.8349	12.8846	97.21	2.0244	15.19	— 1.6554	11.2292	70.1725	287.707	84.81
		14.1397	88.3730	13.2764	93.90	2.6223	18.54	— 1.7590	11.5174	71.9838	295.134	81.46
		14.0320	87.6999	12.1363	86.49	2.4568	17.50	— 0.5611	11.5752	72.3450	296.615	82.50
Shimizu . .	*Idem*	14.4212	90.1324	10.3392	71.69	2.4363	16.89	+ 1.6457	11.9849	74.9056	307.113	83.11
		16.1896	12.1843	14.0204	86.60	2.4951	15.41	— 0.3259	13.6947	85.5919	350.927	84.59
		14.4212	90.1324	13.6926	94.95	2.3048	15.98	— 1.5762	12.1164	75.7275	310.483	84.02
Tanaka . .	*Idem*	12.6698	79.1862	11.3316	89.44	2.4981	19.71	— 1.6599	10.1717	63.5731	260.650	80.29
		13.2640	82.8999	11.2675	84.94	2.5415	19.16	— 0.5450	10.7225	67.0156	274.764	80.84
		13.0590	80.6217	10.7874	82.60	2.1658	16.58	+ 0.1058	10.8932	68.0825	279.138	83.42

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Kayano .	Riz cuit . . . Boiled rice . .	451.90	1.7633	0.39	450.14	1845.574	99.61
	Okowa. . . .	406.92	1.4800	0.36	405.44	1662.304	99.64
	Riz cuit . . . Boiled rice . .	451.90	1.6715	0.37	450.23	1845.943	99.63
Sakaguchi	*Idem*	482.52	1.9141	0.39	480.61	1970.501	99.61
		490.80	1.8672	0.38	488.93	2004.613	99.62
		482.52	2.0788	0.43	480.44	1969.804	99.57
Imai . .	*Idem*	451.90	2.0271	0.44	449.87	1844.467	99.56
		435.39	2.0770	0.47	433.31	1776.571	99.53
		513.14	2.4631	0.48	510.68	2093.788	99.52
Shimizu .	*Idem*	543.76	2.1796	0.40	541.58	2220.478	99.60
		564.68	1.4930	0.26	563.19	2309.079	99.74
		543.76	1.8439	0.34	541.94	2221.954	99.66
Tanaka .	*Idem*	405.97	2.3444	0.57	403.63	1654.883	99.43
		379.98	2.1566	0.56	377.82	1549.062	99.44
		436.59	2.2971	0.53	434.29	1780.589	99.47

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Kayano .	Riz cuit . . . Boiled rice . .	19.47	1.7452	8.96	17.72	164.796	91.04
	Okowa. . . .	18.15	2.0285	11.17	16.12	149.916	88.83
	Riz cuit . . . Boiled rice . .	19.47	1.5415	7.97	17.93	166.749	92.03
Sakaguchi	*Idem*	19.73	1.5202	7.70	18.21	169.353	92.30
		18.55	1.8609	10.03	16.69	155.217	89.97
		19.73	1.7130	8.68	18.02	167.586	91.32
Imai . .	*Idem*	19.47	1.7221	8.84	17.75	165.075	91.16
		18.25	1.9004	10.41	16.35	152.055	89.59
		19.99	1.7281	8.64	18.26	169.818	91.36
Shimizu .	*Idem*	20.25	2.0082	9.91	18.24	169.632	90.09
		18.95	2.2404	11.82	16.71	155.403	88.18
		20.25	1.7820	8.80	18.47	171.771	91.20
Tanaka .	*Idem*	19.08	1.9722	10.33	17.11	159.123	89.67
		17.95	1.9611	10.92	15.99	148.707	89.08
		19.34	1.4285	7.38	17.91	166.563	92.62

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Kayano .	Riz cuit.	25.47	2.6249	10.30	89.70
	Boiled rice				
	Okowa	25.32	3.0150	11.90	88.10
	Riz cuit.	25.47	2.5463	10.00	90.00
	Boiled rice				
Sagaguchi	*Idem*	25.58	2.4675	9.64	90.36
		25.58	3.0250	11.82	88.18
		25.58	2.7597	10.79	89.21
Imai . .	*Idem*	25.47	2.6376	10.35	89.65
		25.39	3.4525	13.59	86.41
		25.69	3.2240	12.25	87.75
Shimizu. .	*Idem*	25.80	2.8945	11.21	88.79
		25.84	2.9350	11.36	88.64
		25.80	2.8658	11.10	88.90
Tanaka .	*Idem*	25.31	2.8305	11.18	88.82
		25.19	2.7288	10.83	89.17
		25.42	2.6898	10.58	89.42

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Caloric utilisation		% de la quantité de calories absorbée % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Kayano .	Riz cuit . . . . Boiled rice . . .	2373.484	46.63	2302.201	45.23	97.00
	Okowa	2232.947	43.78	2114.283	41.46	94.70
	Riz cuit . . . . Boiled rice . . .	2373.484	46.54	2306.336	45.22	97.16
Sakaguchi	*Idem*	2511.417	45.45	2437.389	44.12	97.07
		2569.664	46.01	2483.054	44.46	96.63
		2511.417	44.96	2431.706	43.54	96.86
Imai . . .	*Idem*	2373.484	46.04	2297.249	44.60	96.87
		2397.153	46.37	2223.760	43.01	92.75
		2649.350	51.87	2560.221	49.57	95.56
Shimizu .	*Idem*	2787.284	47.81	2697.223	46.26	96.76
		2906.279	50.02	2815.409	48.46	96.88
		2787.284	47.94	2704.208	46.58	97.16
Tanaka .	*Idem*	2166.584	43.92	2074.656	42.05	95.74
		2064.743	42.11	1972.533	40.23	95.53
		2300.430	46.73	2226.290	45.22	96.77

Digestibility and Utilisation of Each Constituent.

Période Period	Azote total Total nitrogen %	Hydrates de carbone comme le glycose Carbo-hydrate as glucose %	Graisse brute Crude fat %	Cendres brutes Crude ash %	Calories %
Riz cuit — Boiled rice	83.852	99.562	90.852	89.464	96.688
Okowa	83.202	99.594	89.140	88.100	95.298
Riz cuit — Boiled rice	84.118	99.570	91.706	89.056	96.702

Conclusion.

1. The digestibility and utilisation of " Okowa " were not so good as regards total nitrogen, crude fat, and crude ash as ordinary boiled rice; with respect to carbohydrate there was no difference between them. The amount of energy supplied was slightly less during the " Okowa " period.

2. The amount of " Okowa " eaten was less than that of boiled rice, but the actual quantity reckoned as uncooked rice was larger when " Okowa " was used.

3. The ratio of total nitrogen in the urine to total nitrogen intake decreased slightly during the " Okowa " period.

4. There was no great difference in the output of fæces during the two periods, but the ratio of air-dried quantity to wet quantity was larger during the " Okowa " period.

Experiment VIII.

Comparison of the Digestibility and Utilisation of " Okowa " with " Mochi ".

" Okowa " was prepared by the same method as in Experiment VII, but this time we used only glutinous rice.

For the preparation of "Mochi" 1 "to" (equal to 3.9703 gallons) of washed glutinous rice was soaked in water for 24 hours; the water was drained off, and the rice was steamed in the same manner as in making "Okowa". The "Mochi" was made by the special method of "pounding"; it was then rolled out on a flat surface until it was about 2 cm. in thickness. After cooling to room temperature it was cut into small pieces (100 gms. each), which were boiled before use.

Daily Output of the Total Nitrogen and the Distribution of Nitrogenous Constituents in the Urine.

Sujets Subjects	Période Period	Date	Azote total Total N.	Azote de l'urée Urea N.		Azote de NH_3 Ammonia N.		Azote de l'acide urique Uric acid N.		Azote des bases puriques Purin base N.		Azote des acides aminés Amino acid N.		Azote de la créatinine Creatinin N.		Azote de la créatine Creatin N.	
			(g)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Narita		Fév.-Feb.															
	Okowa	4	9.5359	7.5300	78.96	0.5480	5.74	0.1989	2.08	0.0137	0.14	0.1829	1.92	0.3542	3.71	0.0064	0.07
		5	10.0017	7.8506	78.49	0.4384	4.38	0.2323	2.32	0.0196	0.19	0.1892	1.89	0.3501	3.50	0.0083	0.08
		Moy-Aver	9.7688	7.6903	78.73	0.4932	5.06	0.2156	2.20	0.0167	0.17	0.1861	1.91	0.3522	3.61	0.0074	0.08
	Mochi	6	11.0704	8.2863	74.87	0.4110	3.71	0.2020	1.82	0.0137	0.12	0.1951	1.85	0.3542	3.20	0.0064	0.06
		7	10.2758	8.0415	78.25	0.4110	4.00	0.1747	1.70	0.0144	0.14	0.2056	2.00	0.3521	3.42	0.0106	0.10
		Moy-Aver	10.6731	8.1639	76.56	0.4110	3.86	0.1884	1.76	0.0141	0.13	0.2004	1.93	0.3532	3.31	0.0085	0.08
	Okowa	8	10.7142	8.7439	81.61	0.4521	4.22	0.1965	1.83	0.0163	0.15	0.1416	1.32	0.3584	3.34	0.0020	0.02
		9	10.6594	8.3001	77.86	0.3973	3.72	0.2135	2.00	0.0170	0.16	0.1755	1.65	0.3501	3.30	0.0083	0.08
		Moy-Aver	10.6868	8.5220	79.74	0.4247	3.97	0.2050	1.92	0.0167	0.16	0.1586	1.49	0.3543	3.32	0.0052	0.05
Abe		4	9.6181	7.1245	74.07	0.5206	5.41	0.2080	2.16	0.0178	0.18	0.1888	1.96	0.4153	4.31	0.0088	0.09
	Okowa	5	10.7690	8.0918	75.14	0.4604	4.27	0.2213	2.05	0.0130	0.12	0.2011	1.86	0.4240	3.93	0.0061	0.05
		Moy-Aver	10.1936	7.6082	74.61	0.4905	4.84	0.2147	2.11	0.0154	0.15	0.1950	1.91	0.4197	4.12	0.0075	0.07
		6	11.4814	8.3822	73.00	0.4384	3.82	0.2719	2.37	0.0184	0.16	0.2124	1.85	0.4301	3.74	0.0126	0.11
	Mochi	7	10.4402	7.6177	72.96	0.4685	4.48	0.1941	1.85	0.0164	0.16	0.2115	2.02	0.4014	3.84	0.0110	0.10
		Moy-Aver	10.9608	8.0000	72.98	0.4535	4.15	0.2330	2.11	0.0174	0.16	0.2120	1.94	0.4158	3.79	0.0118	0.11
		8	11.3170	8.6946	76.83	0.4932	4.36	0.1820	1.60	0.0144	0.13	0.1771	1.56	0.4460	3.94	0.0067	0.06
	Okowa	9	11.1391	8.5672	76.91	0.4795	4.30	0.2450	2.20	0.0171	0.15	0.1813	1.62	0.4211	3.78	0.0091	0.08
		Moy-Aver	11.2281	8.6309	76.87	0.4864	4.33	0.2135	1.90	0.0158	0.14	0.1792	1.59	0.4336	3.86	0.0079	0.07

(Continuation.)

Sujets Subjects	Période Period	Date	Azote total Total N. (g)	Azote de l'urée Urea N. (g)	(%)	Azote de NH^3 Ammonia N. (g)	(%)	Azote de l'acide urique Uric acid N. (g)	(%)	Azote des bases puriques Purin base N. (g)	(%)	Azote des acides aminés Amino acid N. (g)	(%)	Azote de la créatinine Creatinin N. (g)	(%)	Azote de la créatine Creatin N. (g)	(%)
Kato	Okowa	Fév.-Feb. 4	9.9523	8.2841	83.24	0.4932	4.96	0.2356	2.36	0.0233	0.24	0.2065	2.08	0.4817	4.84	0.0078	0.07
		5	11.8377	9.4044	79.45	0.5361	4.56	0.3184	2.69	0.0219	0.19	0.2129	1.79	0.5018	4.24	0.0085	0.07
		Moy-Aver	10.8950	8.8443	81.35	0.5147	4.76	0.2770	2.53	0.0226	0.22	0.2097	1.94	0.4918	4.54	0.0082	0.07
	Mochi	6	12.0982	9.2659	76.59	0.5069	4.19	0.2780	2.39	0.0219	0.18	0.2360	1.95	0.5103	4.32	0.0184	0.15
		7	12,0843	9.4838	78.64	0.5480	4.54	0.2644	2.18	0.0178	0.15	0.2173	1.80	0.5018	4.15	0.0085	0.07
		Moy-Aver	12.0913	9.3749	77.62	0.5275	4.37	0.2712	2.29	0.0199	0.17	0.2267	1.88	0.5061	4.24	0.0135	0.11
	Okowa	8	12.0708	9.2084	76.28	0.4658	3.86	0.2208	1.83	0.0171	0.14	0.2242	1.86	0.5103	4.22	0.0088	0.07
		9	12.5227	10.2318	81.71	0.4558	3.64	0.2523	2.00	0.0197	0.16	0.2047	1.64	0.4934	3.94	0.0126	0.10
		Moy-Aver	12.2968	9.7201	79.00	0.4608	3.75	0.2366	1.92	0.0184	0.15	0.2145	1.75	0.5019	4.58	0.0107	0.09
Tanaka	Okowa	4	9.5494	7.8602	82.31	0.4658	4.87	0.1395	1.46	0.0178	0.18	0.2006	2.10	0.4895	5.12	0.0123	0.13
		5	10.6046	8.4041	79.25	0.5152	4.85	0.2749	2.59	0.0164	0.15	0.1951	1.83	0.4934	4.65	0.0126	0.12
		Moy-Aver	10.0770	8.1322	80.78	0.4905	4.86	0.2072	2.03	0.0171	0.17	0.1979	1.97	0.4915	4.89	0.0125	0.13
	Mochi	6	10.6594	8.3151	78.01	0.4247	3.97	0.2719	2.54	0.0199	0.19	0.2183	2.04	0.4632	4.34	0.0072	0.07
		7	10.9334	3.5480	78.18	0.4521	4.15	0.2474	2.26	0.0191	0.17	0.1880	1.72	0.4817	4.40	0.0078	0.07
		Moy-Aver	10.7964	8.4316	78.10	0.4384	4.06	0.2597	2.40	0.0195	0.18	0.2032	1.88	0.4725	4.37	0.0075	0.07
	Okowa	8	10.6868	8.4260	79.00	0.4384	4.10	0.2183	2.04	0.0137	0.13	0.1947	1.82	0.4460	4.17	0.0067	0.06
		9	10.6184	8.5699	80.07	0.4932	4.65	0.2305	2.28	0.0199	0.19	0.1872	1.76	0.4704	4.42	0.0113	0.10
		Moy-Aver	10.6526	8.4980	79.54	0.4658	4.38	0.2244	2.16	0.0168	0.16	0.1910	1.79	0.4582	4.30	0.0090	0.08

The Daily Output of SO_3, P_2O_5, and NaCl in the Urine.

Période Period	Date	Narita			Abe		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Okowa	Fév.-Feb						
	4	1.4491	1.5434	17.7	1.5597	1.2608	20.2
	5	1.7376	1.6738	21.7	1.7331	1.7390	19.2
	Moyenne — Aver.	1.5934	1.6086	19.7	1.6464	1.4999	19.7
Mochi	6	1.6602	1.4130	20.0	1.6177	2.0216	26.4
	7	1.8474	1.2825	20.4	1.7630	1.8912	18.1
	Moyenne — Aver.	1.7538	1.3478	20.2	1.6904	1.9564	22.3
Okowa	8	1.7301	1.4130	21.8	1.8296	1.9564	20.2
	9	1.7219	1.4347	22.2	1.7992	1.8043	20.4
	Moyenne — Aver.	1.7260	1.4239	22.0	1.8144	1.8804	20.3

Période Period	Date	Kato			Tanaka		
		SO_3(g)	P_2O_5(g)	NaCl(g)	SO_3(g)	P_2O_5(g)	NaCl(g)
Okowa	Fév.-Feb.						
	4	1.5366	1.1086	19.1	1.5843	1.6956	15.6
	5	1.7555	1.9129	16.3	1.7023	1.9347	19.1
	Moyenne — Aver.	1.6461	1.5108	17.7	1.6433	1.8152	17.4
Mochi	6	1.8742	1.4999	17.6	1.6341	1.7608	19.4
	7	1.7777	1.5651	19.7	1.8180	1.8260	20.4
	Moyenne — Aver.	1.8260	1.5325	18.7	1.7261	1.7934	19.9
Okowa	8	1.9394	1.6738	21.9	1.7058	1.9347	19.5
	9	1.8886	1.5434	24.2	1.6662	1.8695	22.7
	Moyenne — Aver.	1.9190	1.6086	23.1	1.6860	1.9021	21.1

Sujets / Subject	Période / Period	Absorption d'azote Moyenne journalière — N. intake Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Azote trouvé dans l'urine Moyenne journalière — N. in urine Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Azote trouvé dans les selles Moyenne journalière — N. in fæces Average per day: Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Gains ou pertes en azote Nitrogen balance	Absorption Moyenne journalière — Absorption Average per day: Azote (gr.) Nitrogen (gms.)	Protéine (gr.) Protein (gms.)	Calories	Pourcentage d'absorption % of absorption
Narita . . .	Okowa	11.8847	74.2793	9.7688	82.19	2.5578	21.52	— 0.4419	9.3269	58.2931	239.002	78.48
	Mochi	12.7460	79.6624	10.6731	83.74	2.1523	16.88	— 0.0794	10.5937	66.2106	271.463	83.12
	Okowa	11.7747	73.5918	10.6868	90.76	2.5495	21.65	— 1.4616	9.2252	57.6575	236.396	78.35
Abe . . .	Okowa	11.8847	74.2793	10.1936	85.77	2.5277	21.26	— 0.8366	9.3570	58.4813	239.773	78.74
	Mochi	13.4398	83.9987	10.9608	81.55	1.9263	14.33	+ 0.5527	11.5135	71.9594	295.034	85.67
	Okowa	11.4445	71.5280	11.2281	98.11	1.8563	16.22	— 1.6399	9.5882	59.9263	245.698	83.78
Kato . . .	Okowa	12.1048	75.6549	10.8950	90.01	2.0112	16.61	— 0.8014	10.0936	63.0850	258.649	83.39
	Mochi	13.4398	83.9987	12.0913	90.00	1.6652	12.39	— 0.3167	11.7746	73.5913	301.724	87.61
	Okowa	12.3249	77.0305	12.2968	99.77	2.3769	19.28	— 2.3488	9.9480	62.1750	254.918	80.78
Tanaka . .	Okowa	11.6646	72.9037	10.0770	86.39	2.3208	19.89	— 0.7332	9.3438	58.3988	239.435	80.11
	Mochi	13.0929	81.8305	10.7964	82.46	2.0454	15.62	+ 0.2511	11.0475	68.8469	282.272	84.38
	Okowa	11.2244	70.1524	10.6526	94.90	1.8721	16.68	— 1.3003	9.3523	58.4519	239.653	83.32

Digestibility and Utilisation of the Carbohydrate (as Glucose) and its Caloric Value.

Sujets Subject	Période Period	Absorption des hydrates de carbone Moy. jour. (gr.) Carbohydrate intake Average per day (gms.)	Hydrates de carb. élim. dans les selles Moyenne journal. Carbohydrate in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Narita	Okowa	307.59	1.1228	0.36	306.47	1256.527	99.64
	Mochi	363.64	1.3329	0.36	362.31	1485.471	99.64
	Okowa	300.16	1.4495	0.48	298.71	1224.711	99.52
Abe	Okowa	307.59	1.3153	0.42	306.27	1255.707	99.58
	Mochi	410.17	1.1609	0.28	409.01	1676.941	99.72
	Okowa	277.84	1.0437	0.38	276.80	1134.880	99.62
Kato	Okowa	322.46	1.0728	0.33	321.39	1317.699	99.67
	Mochi	410.17	0.7726	0.19	409.40	1678.540	99.81
	Okowa	337.34	1.4438	0.42	335.90	1377.190	99.58
Tanaka	Okowa	292.71	1.4700	0.50	291.24	1194.084	99.50
	Mochi	386.91	1.4967	0.38	385.41	1580.181	99.62
	Okowa	262.96	1.2298	0.47	261.73	1073.093	99.53

Digestibility and Utilisation of Crude Fat and its Caloric Value.

Sujets Subject	Période Period	Absorption de la graisse Moy. jour. (gr.) Fat intake Average per day (gms.)	Graisse éliminée dans les selles Moyenne journal. Fat in fæces Average per day		Absorption Moyenne journalière Absorption Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	Quantité (gr.) Quantity (gms.)	Calories	
Narita .	Okowa. . . .	17.85	1.9594	10.97	15.89	147.777	89.03
	Mochi	18.27	1.0021	5.48	17.27	160.611	94.52
	Okowa. . . .	17.80	1.3393	7.52	16.46	153.078	92.48
Abe . . .	Okowa. . . .	17.85	2.3411	13.11	15.51	144.243	86.89
	Mochi	18.59	1.5246	8.20	17.07	158.751	91.80
	Okowa. . . .	17.65	1.7966	10.18	15.85	147.405	89.82
Kato . .	Okowa. . . .	17.95	2.0294	11.30	15.92	148.056	88.70
	Mochi	18.59	1.4635	7.87	17.13	159.309	92.13
	Okowa. . . .	18.05	1.9721	10.92	16.08	149.544	89.08
Tanaka .	Okowa. . . .	17.75	2.4429	13.76	15.31	142.383	86.24
	Mochi	18.43	1.7063	9.25	16.72	155.496	90.75
	Okowa. . . .	17.55	1.6648	9.49	15.89	147.777	90.51

Digestibility and Utilisation of Crude Ash.

Sujets Subject	Période Period	Absorption des cendres Moy. journ. (gr.) Ash intake Average per day (gms.)	Cendres éliminées dans les selles Moyenne journalière Ash in fæces Average per day		Pourcentage d'absorption % of absorption
			Quantité (gr.) Quantity (gms.)	% de la quantité absorbée % against intake	
Narita . .	Okowa	24.98	3.2873	13.16	86.84
	Mochi	25.17	2.4063	9.56	90.44
	Okowa	24.95	3.1160	12.49	87.51
Abe . . .	Okowa	24.98	3.3148	13.27	86.73
	Mochi	25.34	2.0466	8.08	91.92
	Okowa	24.87	2.3562	9.47	90.53
Kato . . .	Okowa	25.03	2.9805	11.90	88.10
	Mochi	25.34	2.7642	10.90	89.10
	Okowa	25.05	3.6402	14.51	85.49
Tanaka .	Okowa	24.92	3.2376	12.98	87.02
	Mochi	25.26	2.3182	9.17	90.83
	Okowa	24.81	2.3989	9.67	90.33

Percentage of the Caloric Value of Food actually utilised by the Body.

Sujets Subject	Période Period	Absorption des calories Moyenne journalière Calories intake Average per day		Utilisation des calories Caloric utilisation		% de la quantité de calories absorbée % against calories intake
		Calories totales Total calories	Par kg. du poids Per kg. of body weight	Calories totales Total calories	Par kg. du poids Per kg. of body weight	
Narita . .	Okowa	1371.669	39.67	1643.306	37.64	94.88
	Mochi	1987.451	45.95	1890.545	43.71	95.13
	Okowa	1697.881	39.25	1614.185	37.32	95.08
Abe . . .	Okowa	1731.669	34.11	1639.723	32.32	94.75
	Mochi	2198.979	43.77	2130.726	42.21	96.43
	Okowa	1596.554	31.90	1527.983	30.52	95.67
Kato . .	Okowa	1799.206	33.33	1724.404	31.94	95.83
	Mochi	2198.979	40.94	2139.573	39.83	97.29
	Okowa	1866.784	34.81	1781.652	33.22	95.43
Tanaka .	Okowa	1664.091	33.92	1575.902	32.12	94.70
	Mochi	2093.235	42.85	2017.949	41.31	96.40
	Okowa	1528.976	31.43	1460.523	30.02	95.51

Digestibility and Utilisation of Each Constituent.

Période Period	Azote total Total nitrogen %	Hydrates de carbone comme le glycose Carbo-hydrate as glucose %	Graisse brute Crude fat %	Cendres brutes Crude ash %	Calories %
Okowa	80.180	99.598	87.715	87.172	95.040
Mochi	85.170	99.698	92.300	90.572	96.312
Okowa	81.542	99.562	90.472	89.407	95.422

Conclusion.

1. The digestibility and utilisation of each constituent were better during the " Mochi " period than during the " Okowa " period. The amount of energy supplied was greater during the " Mochi " period.

2. Less " Mochi " was eaten than " Okowa ", but the actual quantity reckoned in terms of uncooked rice was larger during the " Mochi " period.

3. The output of total nitrogen and the ratio of the various nitrogenous compounds in the urine to total urine nitrogen showed no definite changes during the two periods, except that the ratio of urea nitrogen to total urine nitrogen decreased slightly during the " Mochi " period.

4. The output of fæces was slightly larger (wet quantity) during the " Mochi " period.

9.

THE BIOLOGICAL VALUE OF THE NITROGENOUS SUBSTANCES FOUND IN OUR MAIN VEGETABLE FOODS.

By Kaichi Furumi

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Proteins are substances containing nitrogen, and can be found in various different kinds of foods. They differ both in quantity and quality in various foods and their physiological value to an organism depends upon their chemical composition.

I have determined the biological values of the proteins contained in a number of foods; the results of my experiments are as follows:

Table I.

Aliment Food	N. absorbé Nitrogen absorbed	N. éliminé dans l'urine Nitrogen in urine	Différence Balance
Riz (glacé) — Rice (polished)	4.152	5.390	— 0.878
Riz (demi glacé) — Rice (half-polished).	5.018	5.890	— 0.872
Riz (non glacé) — Rice (unpolished) .	5.047	5.597	— 0.550
Orge — Barley	5.963	6.856	— 0.893
Patate douce — Sweet potato	0.704	5.226	— 4.522
Koryo	1.041	4.591	— 3.550
Millet	7.561	8.126	— 0.565

In almost all cases nitrogen equilibrium was maintained.

A statement of the degree of absorption and of the biological value of the proteins of the above foods is given in Table II.

Table II.

Food		Nitrogen absorbed %	Biological value
Rice (polished)	Exp. No. I	100.0	81.68
	Exp. No. VI	87.5	
Rice (half-polished)		83.3	93.25
Rice (unpolished)		75.4	66.08
Barley		75.1	66.21
Sweet potato		56.8	81.41
Koryo		17.6	41.08
Millet		86.9	56.86

10.

BIOCHEMICAL STUDIES ON RICE.

Differences in the Physico-chemical Properties of the Protein Oryzenin as it occurs in Glutinous and in Common Rice.

By Tetsutaro TADOKORO, Yukihiko NAKAMURA and Shukichi WATANABE

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INTRODUCTION.

Many authors who have studied the chemical nature of glutinous and common rices have deduced that the differences between these rices are mainly due to the physico-chemical properties of their starches. We believe that the two different mechanisms of starch formation are due to the particular physiological processes going on in the two varieties of rice plants. If so, the difference in the physiological processes is due primarily to the physico-chemical properties of the proteins (the principal constituents of the protoplasm) and in particular to the properties of oryzenin, the main protein of rice. If oryzenin is not a simple chemical substance, one should be able to find differences between samples of this substance obtained from glutinous and common rices just as one finds differences between the starches of the two varieties.

I. WATER AND ASH CONTENT OF ORYZENIN.

Table I.

	Oryzénine du riz commun Common rice oryzenin				Oryzénine du riz glutineux Glutinous rice oryzenin			
	Eau Water %	Cendres Ash %	Soufre Sulphur %	Phosphore Phosphorus %	Eau Water %	Cendres Ash %	Soufre Sulphur %	Phosphore Phosphorus %
Akita . . .	2.550	0.493	0.892	0.166	2.400	0.369	0.779	0.188
Etchu . . .	3.850	0.564	0.828	0.162	4.250	0.418	0.777	0.186
Asahikawa .	5.700	0.599	0.745	0.153	4.700	0.502	0.695	0.175
Hyogo . . .	5.340	0.498	0.635	0.167	5.950	0.374	0.596	0.189
Saitama . .	9.269	0.318	0.809	0.103	3.432	0.291	0.771	0.168
Ibaragi . .	7.692	0.303	0.773	0.101	4.233	0.294	0.681	0.174
Echigo . . .	8.807	0.373	0.749	0.095	4.423	0.314	0.654	0.164

II. Iso-electric Point of Oryzenin.

If a difference were discovered between the iso-electric points of the oryzenins of glutinous and common rices, it could be assumed that there are quantitative or qualitative differences among the constituent amino-acids and at the same time a difference in the condensing conditions of such amino-acids. The authors compared the iso-electric points of the two oryzenins by means of the following experiments.

Table II.

Change of Surface Tension of Oryzenins dissolved in Buffer Solutions.

PH de la solution tampon / PH value of buffer solution	4.6	4.8	5.0	5.2	5.4	5.6
Méthode électrique / Electrical method (m. volt) 18° C.	522	550	565	571	581	590
PH calculé d'après les données ci-dessus en m. v. / PH calculated from above m. v.	4.67	5.18	5.43	5.51	5.70	5.85
Tension superficielle à 16° C. / Surface tension (16° C.)	dy /cm	dy /cm	dy /cm	dy /cm	dy /cm	dy /cm
Saitama						
Commun — Common	61.2	62.5	62.5	*64.2*	62.5	60.5
Glutineux—Glutinous	61.2	*63.9*	62.5	63.2	63.2	60.5
Echigo						
Commun — Common	61.8	61.2	61.8	61.8	*63.2*	61.8
Glutineux—Glutinous	61.2	*62.2*	61.8	61.8	61.8	60.5
Ibaragi						
Commun — Common	61.2	61.8	60.5	*64.2*	63.9	63.2
Glutineux—Glutinous	61.8	*63.2*	61.2	61.2	61.2	60.5
Asahikawa						
Commun — Common	62.5	61.9	61.2	60.5	*64.2*	63.3
Glutineux—Glutinous	62.5	61.8	*63.9*	62.5	61.9	61.9
Shonai						
Commun — Common	62.5	61.8	61.8	62.5	*63.2*	61.2
Glutineux—Glutinous	61.2	*62.5*	61.2	61.2	61.2	60.5
Etchu						
Commun — Common	62.5	62.5	61.9	62.5	62.2	*64.2*
Glutineux—Glutinous	63.2	63.2	*64.2*	63.2	61.9	62.5
Akita						
Commun — Common	63.9	63.2	62.5	63.2	*64.2*	63.9
Glutineux—Glutinous	63.9	63.2	*64.2*	63.2	62.5	61.9
Hyogo						
Commun — Common	61.9	62.5	62.5	63.2	*64.2*	62.5
Glutineux—Glutinous	62.5	61.5	*63.2*	62.5	61.9	62.5

Change of Viscosity of Oryzenins dissolved in Buffer Solutions. Viscosity (flowing time, 15° C.).

Saitama						
Commun — Common	1′ 21.8″	1′ 21.8″	1′ 21.8″	*1′ 21.9″*	1′ 22.0″	1′ 22.8″
Glutineux—Glutinous	1′ 21.8″	*1′ 19.8″*	1′ 20.0″	1′ 20.4″	1′ 21.2″	1′ 20.8″
Echigo						
Commun — Common	1′ 16.8″	1′ 17.2″	1′ 17.2″	1′ 16.8″	*1′ 16.2″*	1′ 17.2″
Glutineux—Glutinous	1′ 17.0″	*1′ 15.8″*	1′ 16.8″	1′ 16.8″	1′ 16.8″	1′ 17.0″
Ibaragi						
Commun — Common	1′ 21.8″	1′ 21.2″	1′ 21.4″	*1′ 20.2″*	1′ 21.6″	1′ 22.0″
Glutineux—Glutinous	1′ 21.8″	*1′ 20.8″*	1′ 21.0″	1′ 21.2″	1′ 21.8″	1′ 22.0″
Shonai						
Commun — Common	1′ 16.8″	1′ 17.4″	1′ 16.8″	1′ 17.4″	*1′ 16.4″*	1′ 17.8″
Glutineux—Glutinous	1′ 16.8″	1′ 15.8″	*1′ 15.0″*	1′ 15.8″	1′ 16 8″	1′ 16.8″
Etchu						
Commun — Common	1′ 24.2″	1′ 23.6″	1′ 24.2″	1′ 23.8″	1′ 23.6″	*1′ 22.8″*
Glutineux—Glutinous	1′ 23.4″	1′ 23.8″	*1′ 23.2″*	1′ 24 8″	1′ 25.0″	1′ 25.4″
Akita						
Commun — Common	1′ 26.6″	1′ 25.8″	1′ 25.4″	1′ 25.2″	*1′ 24.2″*	1′ 26.8″
Glutineux—Glutinous	1′ 26.4″	1′ 25.8″	*1′ 24.4″*	1′ 25.4″	1′ 24.8″	1′ 25.2″
Asahikawa						
Commun — Common	1′ 21.6″	1′ 21.6″	1′ 21.4″	1′ 22.0″	*1′ 21.0″*	1′ 22.2″
Glutineux—Glutinous	1′ 20.8″	1′ 20.8″	*1′ 20.0″*	1′ 21.2″	1′ 21.2″	1′ 21.2″

The table shows that, in the same kind of rice protein solution, the PH values of maximum surface tension and minimum viscosity were approximately the same in rices produced in different provinces. The difference in the PH values of the iso-electric points in the two kinds of oryzenin is 0.07-0.52; glutinous rice proteins are more acidic than common rice proteins. However, slight differences can be seen between the iso-electric points of common rice proteins produced in different places. The iso-electric point of common rice protein is on the alkaline side; it has a higher PH value than the glutinous. The protein of the former contains a larger proportion of the amino groups than carboxyl groups.

III. Other Physico-chemical Properties.

(a) *The Solubility of Oryzenin in Alkali Solution.*

The authors confirmed the observation that common rice oryzenins are more difficult to dissolve in alkali solution than glutinous rice oryzenins.

(b) *The Refractive Index of Oryzenin Alkali Solution.*

Oryzenin was dissolved in 1/10 normal NaOH solution so that the solution contained 7.5 per cent oryzenin. The refractive index of the solution was examined by means of Ferry's refractometer at 25-26° C.

Table III.

The Refractive Indices of Various Oryzenins in Alkali.

Kind of rice	Toyama		Niigata		Mie	
	Common	Glutinous	Common	Glutinous	Common	Glutinous
Refractive index	1.3460	1.3432	1.3448	1.3435	1.3465	1.3443
Its difference	0.0028		0.0013		0.0022	

The table shows that the refractive index of common rice protein is always higher than that of the glutinous.

(c) *The Specific Rotatory Power of Oryzenin Alkali Solution.*

Table IV.

Specific Rotatory Power of Various Oryzenins dissolved in Alkali.

Espèce de riz / Kind of rice		0.1 gr. dans 15 c.c. de: / 0.1 gm. in 15 c.c. of:			
		Soude en solution N /25 / 1 /25 normal NaOH		Soude décinormale / 1 /10 normal NaOH	
Saitama	Commun — Common .	— 64.875	— 2.5	— 77.850	— 3.0
	Glutineux — Glutinous	— 59.685	— 2.3	— 59.685	— 2.3
Ibaragi	Commun — Common .	— 60.982	— 2.35	— 80.445	— 3.1
	Glutineux — Glutinous	— 54.480	— 2.1	— 60.982	— 2.35
Shonai	Commun — Common .	— 62.205	— 2.4	— 75.255	— 2.9
	Glutineux — Glutinous	— 59.685	— 2.3	— 60.982	— 2.35
Echigo	Commun — Common .	— 63.577	— 2.45	— 67.470	— 2.6
	Glutineux — Glutinous	— 60.982	— 2.35	— 62.205	— 2.4
Akita	Commun — Common .	— 62.205	— 2.4	— 76.552	— 2.95
	Glutineux — Glutinous	— 55.792	— 2.15	— 58.387	— 2.25
Etchu	Commun — Common .	— 62.205	— 2.4	— 75.255	— 2.9
	Glutineux — Glutinous	— 51.900	— 2.0	— 54.480	— 2.1
Asahikawa	Commun — Common .	— 59.685	— 2.3	— 62.205	— 2.4
	Glutineux — Glutinous	— 49.305	— 1.9	— 53.197	— 2.05
Hyogo	Commun — Common .	— 60.982	— 2.35	— 71.362	— 2.75
	Glutineux — Glutinous	— 51.900	— 2.0	— 55.792	— 2.15

The rotatory power of the alkali oryzenin solution of common rice is greater than that of glutinous rice. In the presence of much alkali the rotatory power of the former increases more than that of the latter.

IV. Determination of the Quantities of HCl that combine with Oryzenin.

It may be said that, in a given concentration of HCl, the amount of HCl combining with the added protein is proportional to the number of free amino groups in the protein.

The authors calculated the quantity of HCl combining with protein from the following formula:

$$\frac{C}{C'} = \frac{\log A - \log (A-X)}{\log A - \log (A-X')}.$$

Table V.

Combining Power of Oryzenins with HCl.

Espèce de riz Kind of rice		HCl à l'état libre HCl in free state (mg.)	HCl en combinaison HCl in combined state (mg.)
Akita	Commun — Common.	13.903	4.312
	Glutineux — Glutinous . . .	14.818	3 .417
Etchu	Commun — Common.	13.337	4.898
	Glutineux — Glutinous . . .	13.604	4.613
Asahikawa	Commun — Common.	14.253	3.982
	Glutineux — Glutinous . . .	15.642	2.582
Saitama	Commun — Common.	16.251	1.984
	Glutineux — Glutinous . . .	16.709	1.526
Ibaragi	Commun — Common.	16.526	1.909
	Glutineux — Glutinous . . .	16.940	1.295
Echigo	Commun — Common.	16.470	1.765
	Glutineux — Glutinous . . .	16.935	1.300

In the case of common rice oryzenin, the quantity of HCl combined is always greater than in the case of glutinous. This is further evidence that the free amino group predominates in the former as compared with the latter.

V. The Elementary Composition of the Oryzenins.

Table VI.

Elementary Composition of Oryzenin and Ratio of Carbon to Oxygen.

Espèce de riz Kind of rice		Azote Nitrogen %	Hydrogène Hydrogen %	Carbone Carbon %	Oxygène Oxygen %	Pourcentage Ratio %
Akita	Commun — Common .	18.33	9.61	52.35	18.85	2.777
	Glutineux — Glutinous	17.59	8.72	51.04	21.89	2.331
Etchu	Commun — Common .	17.86	9.80	51.98	19.54	2.659
	Glutineux — Glutinous	16.86	8.62	49.83	23.99	2.077
Asahikawa	Commun — Common.	17.30	8.76	51.85	21.39	2.424
	Glutineux — Glutinous	16.22	8.35	50.59	24.18	2.092
Hyogo	Commun — Common .	18.64	8.27	53.15	19.31	2.751
	Glutineux — Glutinous	17.67	7.47	51.45	22.80	2.256
Saitama	Commun — Common .	19.31	8.83	55.74	15.31	3.640
	Glutineux — Glutinous	18.38	7.12	50.67	23.06	2.197
Ibaragi	Commun — Common .	19.07	8.73	50.45	20.98	2.404
	Glutineux — Glutinous	18.02	7.65	48.48	25.17	1.926
Echigo	Commun — Common .	18.45	8.31	50.96	21.53	2.366
	Glutineux — Glutinous	17.50	7.55	45.63	29.67	1.537

The nitrogen content of common rice oryzenin is about 1 per cent higher than that of glutinous rice oryzenin. This is why the alkalinity of the former is greater than that of the latter. The lower ratio of carbon to oxygen of the glutinous rice oryzenin as compared with that of the common rice oryzenin confirms the predominance of the acidity and of the carboxyl groups in the former.

VI. Separation and Determination of Amino Acids.

The following table shows the percentages of the various forms of nitrogen as determined by Van Slyke's method.

Table VII.

Percentages of Nitrogen formed when Oryzenin was hydrolysed with HCl.

Espèce de riz Kind of rice	Azote total Total N	Azote combinée sous forme de:							
		Ammoniaque Ammonia N	Mélanine Melanin N	Acides monoaminés Monoamino N	Acides diaminés Diamino N	Arginine Arginin N	Lysine Lysin N	Histidine Histidin N	Cystine Cystin N
Akita									
Commun — Common .	100	9.732	2.234	41.680	46.371	30.638	5.335	9.476	0.976
Glutineux — Glutinous	100	7.311	2.319	44.002	46.350	25.668	3.149	16.253	1.279
Etchu									
Commun — Common .	100	9.143	2.447	43.897	44.530	26.337	3.107	12.167	0.918
Glutineux — Glutinous	100	8.879	2.111	45.907	43.114	21.150	2.384	18.398	1.180
Asahikawa									
Commun — Common .	100	9.826	1.983	52.312	35.890	16.404	10.347	7.913	1.225
Glutineux — Glutinous	100	7.108	1.962	53.167	37.657	16.868	6.381	11.954	2.287
Hyogo									
Commun — Common .	100	9.105	2.405	41.713	46.722	27.444	6.216	12.150	0.910
Glutineux — Glutinous	100	8.851	2.213	43.084	45.850	20.959	2.482	20.742	1.165
Saitama									
Commun — Common .	100	9.293	3.097	43.178	44.427	26.340	5.393	8.003	0.689
Glutineux — Glutinous	100	8 528	2.904	44.478	44.092	19.104	2.425	14.004	1.555
Ibaragi									
Commun — Common .	100	9.263	3.087	43.115	44.164	26.190	5.854	7.672	0.612
Glutineux — Glutinous	100	8.178	2.516	45.205	43.544	19.355	3.162	13.387	1.497
Echigo									
Commun — Common .	100	9.677	2.903	45.597	43.821	26.040	5.569	7.742	0.542
Glutineux — Glutinous	100	8.440	2.272	45.165	44.121	19.553	3.004	13.434	1.403

It is obvious that in common rice oryzenin there is a predominance of ammonia, arginin and lysin nitrogen, while in the glutinous oryzenin there is an excess of monoamino, histidin and cystin nitrogen. The quantities of ammonia nitrogen in the glutinous rice oryzenin are about 87 per cent of those in the common, arginin nitrogen 73 per cent, lysin nitrogen about 60 per cent, while monoamino nitrogen in the common is 96 per cent of the glutinous, histidin and cystin nitrogen about 60 per cent.

VII. Determination of Tyrosin and Tryptophan.

The method of Fürth and Nobel was used to determine the content of tryptophan.

Table VIII.

Percentage of Tryptophan and Tyrosin.

	Akita		Etchu		Asahikawa	
	Commun Common	Glutineux Glutinous	Commun Common	Glutineux Glutinous	Commun Common	Glutineux Glutinous
Tryptophane . . } (%) Tryptophan . . }	1.23	1.36	1.05	1.26	1.30	1.16
Tyrosine . . . . } (%) Tyrosin . . . . }	0.79	0.83	1.20	1.05	0.92	1.02

VIII. The Formation of Iodoprotein.

The authors prepared iodoprotein by Blum and Straus' method; its iodine content was determined by Baubigny and Chavanne's method. The results are tabulated in Table IX.

Table IX.

Iodine Content of Iodoprotein.

	Akita		Etchu		Asahikawa	
	Commun Common	Glutineux Glutinous	Commun Common	Glutineux Glutinous	Commun Common	Glutineux Glutinous
Echantillon . . } (g.) Sample . . . . }	0.1304	0.1132	0.1264	0.1492	0.1626	0.1085
Iodure d'argent } (g.) Silver iodide. . }	0.0220	0.0199	0.0292	0.0306	0.0316	0.0236
Iode — Iodine . (mg.)	11.9463	10.7627	12.6727	12.6750	17.0905	12.7638
Pourcentage . . . . } Percentage . . . . }	9.161	9.507	10.027	10.657	10.511	11.764

From the table it is evident that glutinous rice oryzenin combines with more iodine than that of common rice.

IX. The Determination of Free Amino Nitrogen.

The authors know that the amount of lysin nitrogen in common oryzenin is to that in glutinous as 100 to 57. Accepting Van Slyke's and Birchard's suggestion, it may be considered that the quantity of free amino nitrogen of common rice is greater than that of glutinous.

Table X.

Free Amino Nitrogen Content of Various Oryzenins.

	Oryzénine du riz commun Common rice oryzenin			Oryzénine du riz glutineux Glutinous rice oryzenin		
	Solution de soude N/5 $\frac{1}{5}$ normal NaOH (c.c.)	Azote Nitrogen (g.)	% d'azote totale % of total N.	Solution de soude N/5 $\frac{1}{5}$ normal NaOH (c.c.)	Azote Nitrogen (g.)	% d'azote totale % of total N.
Akita	0.55	0.00154	10.50	0.50	0.00140	9.95
Etchu	0.65	0.00182	12.92	0.55	0.00154	11.42
Asahikawa	0.50	0.00140	10.12	0.45	0.00126	9.71
Hyogo	0.61	0.00171	9.07	0.42	0.00117	6.60
Saitama	0.62	0.00175	12.23	0.52	0.00147	11.54
Ibaragi	0.60	0.00168	11.94	0.55	0.00154	11.15
Echigo	0.55	0.00154	11.43	0.50	0.00140	10.46

From the table it is seen that the free amino nitrogen content of common rice oryzenin is always greater than that of glutinous.

X. The Decomposition of Oryzenin by Pancreatin.

Table XI.

Decomposition of Oryzenin by Pancreatin.

	Nitrogen in 10 c.c. (mg.)		Percentage of total nitrogen	
	Common (Asahikawa)	Glutinous (Shonai)	Common (Asahikawa)	Glutinous (Shonai)
Total nitrogen	12.25	11.75	16.869	16.181
Digestion period (hours)	1.5	20.0	42.0	

Kind of rice	Common	Glutinous	Common	Glutinous	Common	Glutinous
Nitrogen of precipitate by Zn-sulphate (mg.) (I)	27.197	24.102	24.203	20.903	18.505	15.421
Nitrogen of precipitate by phospho-tungstic acid (mg.) (II) . . .	6.198	10.623	6.541	10.966	9.983	10.966

The table shows that glutinous rice oryzenin is decomposed more rapidly than common oryzenin by the action of pancreatin, and also that the polymerisation of the protein molecule is more advanced and complicated in common rice oryzenin than in glutinous.

XI. The Silver Salt of Oryzenin.

The authors compared the combining power of the two oryzenins with silver.

Table XII.

Combination of Silver with the two Kinds of Oryzenin.

	Oryzénine du riz commun Common rice oryzenin		Oryzénine du riz glutineux Glutinous rice oryzenin	
	Azote contenu dans 0,2 gr. Nitrogen in 0.2 gms. (mg.)	Azote total Total nitrogen %	Azote contenu dans 0,2 gr. Nitrogen in 0.2 gms. (mg.)	Azote total Total nitrogen %
Echantillon I . . . Sample I	30.389		28.682	
		Moyenne Average 15.2435		Moyenne Average 14.6315
Echantillon II . . . Sample II	30.085		29.365	

	$AgCl_2$ in 0.4 g. (mg.)	% desséchée % of dried matter	$AgCl_2$ in 0.4 g. (mg.)	% desséchée % of dried matter
Echantillon I . . . Sample I	13.40		27.20	
		Moyenne Average 3.27		Moyenne Average 6.88
Echantillon II . . Sample II	12.80		27.90	
		Argent Silver 2.47		Argent Silver 5.18
Proportion de N et de Ag. . . . . Ratio of N and Ag (Ag/NX100)		16.07		35.48

The silver salts of common rice oryzenin contain more nitrogen than those of glutinous rice, which the salt of glutinous oryzenin contain more silver than those of common rice.

XII. Composition of Acetyl Oryzenin.

For the purpose of studying constitutional differences between the two kinds of oryzenins, the authors acetylated the oryzenins and obtained pyrrole and its derivatives from the acetyl oryzenin.

The nitrogen fractions are arranged in the following manner:

Nitrogen fraction A.

Ammonia evolved by hydrolysis.

Nitrogen fraction B.

Weak basic nitrogenous substances soluble in ether-amylalcohol.

1. Ether-soluble nitrogen: B1 (pyrrole).
2. Ether-insoluble nitrogen: B2.

Nitrogen fraction C.

Strong base, soluble in ether-amylalcohol.

1. Ether-soluble nitrogen: C1 (pyrrolidin and glyoxalin).
2. Alcohol-soluble nitrogen: C2.
3. Water-soluble nitrogen: C3.

Nitrogen fraction D.

Water-soluble nitrogen.

1. Ether-soluble nitrogen: D1 (pyrrolic acid).
2. Alcohol-soluble nitrogen: D2 (proteol).
3. Potassium carbonate solution soluble nitrogen: D3.

Table XIII.

Percentage of Nitrogen calculated on the Basis of Total Nitrogen as 100.

	Ibaragi		Niigata		Mie	
	Commun Common	Glutineux Glutinous	Commun Common	Glutineux Glutinous	Commun Common	Glutineux Glutinous
A	10.368	10.037	11.167	11.428	12.263	11.391
B 1 . . .	2.408	1.534	1.736	1.630	1.950	1.228
B 2 . . .	0.736	0.761	0.833	0.376	1.073	0.421
C 1	0.558	0.681	0.832	1.784	0.957	2.203
C 2	2.408	3.253	3.000	1.430	2.676	2.793
C 3	3.913	5.609	3.762	2.118	5.561	8.802
D 1 . . .	3.500	3.064	1.003	0.709	2.296	0.795
D 2 . . .	43.891	46.758	56.667	60.363	44.908	46.370
D 3 . . .	32.218	28.357	21.000	20.361	28.357	25.996

There is a marked difference between the common and the glutinous rice acetyl oryzenin in regard to the production of basic substances, pyrrole, pyrrolidin and glyoxalin, pyrrolic acid, proteol and H_2O-K_2CO_3 soluble substance. Common rice predominates in respect of basic substances, pyrrole, pyrrolic acid and H_2O-K_2CO_3 soluble substance; while glutinous exceeds in respect of pyrrolidin and glyoxalin, and proteol. The authors believed that glutinous rice oryzenin contained more histidin than common. The similarity in structure of histidin and glyoxalin makes it easily conceivable that the two compounds are both present in greater quantities in the glutinous variety.

11.

PHYSICO-CHEMICAL STUDIES CONCERNING THE SPECIFICITY OF PROTEINS OF DIFFERENT VARIETIES AND SUBVARIETIES OF RICE.

By T. Tadokoro, Y. Nakamura and S. Watanabe.

Introduction.

Almost every study concerning the specificity of particular proteins from various sources has been made by physiological methods.

Wells and Osborne experimented with pure globulins obtained from the seeds of hemp, flax, squash and other plants and found a marked difference between them. Their conclusions have been verified recently by many investigators. Constitutional differences in the proteins derived from different species of plants or animals have been shown to be due to a varying distribution of those amino acids which are considered essential for maintaining adequate nutrition. These experiments were carried out with proteins from species of plants or animals which differed so much from one another that one would expect to find considerable differences in their chemical constitutions. The authors determined to investigate the specificity of different varieties of pure oryzenins all prepared from rice. They carried out experiments with many varieties of rice, and established the existence of a physico-chemical specificity among them.

Among many hundreds of varieties of common rice, two types are distinguished in Japan, those employed for the fermentation of Sake and those not so employed. For example, in Settsu, Yamadaho ("Banshu-Ao") is used for fermentation but not Shinriki ("Banshu-Aka"); in Tajima, Kokuryomiyako is selected but not Minoshu; in Akita, Kamenoo but not Toyokuni; in Etchu, Mayezawa but not Oba; in Echigo, Bantakamiya and Yonemitsu but not Ishijiro. That these particular varieties selected for fermentation must have some specific qualities is not hard to conjecture. The present investigation was undertaken to elucidate this point.

A. Materials.

Table I.

	District	Variety name	Commercial grade		
No. 1	Bizen.	Aka	Unhulled	3	Unfermentable
No. 2	Harima, Kasai.	Yamadaho	»	»	Fermentable
No. 3	» Katsushika	Shinriki	»	»	Unfermentable
No. 4	Tajima.	Kokuryomiyako	Hulled	»	Fermentable
No. 5	»	Mino	»	»	Unfermentable
No. 6	Ugo, Yokote.	Toyokuni	Unhulled	»	»
No. 7	» »	Kamenoo	»	»	Fermentable
No. 8	Etchu.	Oba	»	»	Unfermentable
No. 9	»	Mayezawa	»	»	Fermentable
No. 10	Echigo.	Ishijiro	»	»	Unfermentable
No. 11	»	Bantakamiya	»	»	Fermentable
No. 12	»	Yonemitsu	»	»	»

B. Mineral Content of Oryzenins.

Table II.

	Eau Water	Cendre Ash	Soufre Sulphur	Phosphore Phosphorus
		%	%	%
No. 1	8.6300	0.3500	0.9586	0.1087
No. 2	10.0701	0.2660	0.8284	0.1050
No. 3	8.1906	0.3050	1.0400	0.1266
No. 4	9.3190	0.3970	0.8120	0.1189
No. 5	9.1790	0.4180	1.0905	0.1274
No. 6	2.7550	0.5750	0.7039	0.1108
No. 7	2.7830	0.4520	0.6419	0.1069
No. 8	8.6707	—	—	—
No. 9	8.4279	0.2402	1.0418	0.1154
No. 10	9.0164	0.2638	0.9702	0.1423
No. 11	6.5041	0.2354	0.9647	0.1222
No. 12	6.3953	0.2350	0.9665	0.1240

From the table it is seen that the ash content of oryzenin from fermentable rice is always less than that of unfermentable from the same district.

The oryzenin of unfermentable rice seems to contain more sulphur and phosphorus than that of fermentable, but the difference is not great.

C. The Rotatory Degree of Oryzenin Alkali Solutions.

Table III.

	No. 2	No. 3	No. 4	No. 5	No. 8	No. 9	No. 10	No. 11	No. 12
Ventzke degree	–3.50	–4.00	–3.40	–3.90	–3.80	–2.60	–1.60	–1.30	–1.40
Sp. rotatory degree	–67.28	–75.61	–64.88	–74.41	–88.30	67.47–	–83.04	–67.47	–72.66

Mean of unfermentable –80.35
Mean of fermentable –67.95

The specific rotation of fermentable rice oryzenins is considerably less than that of unfermentable rice oryzenins; the value of the former is between 64.88 and 72.66 (mean 67.95), while that of the latter is between 74.41 and 88.30 (mean 80.35).

D.

It was observed that oryzenin from fermentable rices showed a maximum surface tension and turbidity with a smaller amount of HCl solution than that from unfermentable rices. The iso-electric point of the oryzenin of the fermentable rice is therefore more acidic than that of the unfermentable.

E. The Silver Salts of Oryzenins.

Table IV.

Nitrogen and Silver Content of Silver Salts of Oryzenins.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 10	No. 11	No. 12
Nitrogen %	16.525	15.836	14.684	15.492	13.771	16.771	11.705	15.836
Silver %	4.2906	5.1939	3.9143	5.0434	2.9357	5.6456	5.3258	5.7961
Ag/N × 100	25.9	32.7	26.6	32.5	21.3	32.6	45.5	36.6

Ozyzenin from fermentable rice combines with larger quantities of silver than that from unfermentable, showing the predominance of carboxyl groups in the molecule of the former as compared with the latter.

F. The Kinds and Quantities of Amino Acids found in Oryzenins.

Table V.

Percentages of Nitrogen formed when oryzenins were hydrolised by HCl.

	Azote total Total N	Azote contenu dans							
		Ammoniaque Ammonia N	Mélanine Melanin N	Acides monoaminés Monoamino N	Acides diaminés Diamino N	Arginine Arginin N	Histidine Histidin N	Lysine Lysin N	Cystine Cystin N
No. 1	100	9.5889	2.2084	56.1779	32.0308	19.6329	4.7995	6.4468	1.1519
No. 2	100	8.6188	1.8866	56.8933	32.3477	18.8580	6.1200	5.0041	1.3660
No. 3	100	9.2484	2.0228	55.7996	32.9292	20.8031	5.8078	5.1660	1.1519
No. 4	100	8.6931	1.8716	56.7022	32.7276	18.6785	8.1422	4.0294	1.3145
No. 5	100	8.7394	2.0731	55.8971	33.3228	19.6092	7.4916	6.9426	1.0034
No. 6	100	9.7302	2.6234	49.9189	35.9683	23.3919	6.9426	4.4408	1.0816
No. 7	100	9.4555	2.3444	51.2554	36.3588	23.3507	8.3000	3.3692	1.3389
No. 8	100	10.2008	2.1136	58.8211	28.8046	17.3897	7.6029	2.7201	1.0919
No. 10	100	10.7730	2.3942	54.9718	31.9201	21.9545	5.4745	3.4772	1.0195
No. 11	100	10.7310	2.4792	56.8255	29.9643	18.6432	7.5587	2.5676	1.1949
No. 12	100	10.4168	2.0832	58.4885	29.0414	17.9995	7.5521	2.5710	1.1188

There is a definite difference in the proportions of amino acids obtained from oryzenins of the two types of rice; fermentable rice oryzenin is relatively deficient in respect of ammonia, melanin and lysin nitrogen and predominates in respect of histidin and cystin nitrogen.

G. Free Amino Nitrogen of Oryzenins.

Table VI.

	Free amino nitrogen as percentage of total nitrogen
No. 1	11.7313
No. 2	10.2456
No. 3	10.5826
No. 4	9.8583
No. 5	10.4402
No. 6	9.6763
No. 7	9.0775
No. 8	12.7630
No. 9	11.5360
No. 10	17.6052
No. 11	15.2633
No. 12	14.3813

The free amino nitrogen of fermentable rice oryzenin is less than that of unfermentable. This explains why the latter is more basic than the former.

DIFFERENCES BETWEEN SOME PHYSICO-CHEMICAL PROPERTIES OF COMMON AND GLUTINOUS RICE STARCH.

By Tetsutaro Tadokoro and Collaborators.

Introduction.

It is well known that granules of starches vary in their appearance and properties according to their origin; for instance, sago, tapioca and cassava starches yield more glutinous sol than others. We find similar differences between common and glutinous rice starches.

It is well known that there are two different kinds of rice starch, common and glutinous. The difference between the two kinds of starch is shown by the iodine colour reaction, in which common rice starch gives a blue colour while the glutinous rice starch gives a red or purple colour. To explain this phenomenon, Tanaka concluded that the red colouration of the latter is due to a characteristic chemical property of the starch itself and denied Dafert and Mayer's theory of contamination with amylopectin, erythrodextrine or special albuminoids. Concerning other differences between common and glutinous starches, no investigation can be found. The following investigation was carried out to determine any such differences.

I. SAMPLES OF STARCH AND THEIR MINERAL CONSTITUENTS.

The materials used for the preparation of the starches were unhulled and hulled rice produced in different parts of Japan in the years 1921 to 1924. The glutinous rice was found mixed with 0.15–2.0 per cent of common rice, which was removed. The preparation of the starches was carried out mainly according to John's method. The starches obtained were white and their water suspension and paste were neutral to litmus paper and phenolphthalein. The content of water and of ash were determined with the following results.

Table I.

	Amidon de			
	Riz commun Common rice starch		Riz glutineux Glutinous rice starch	
	Eau Water	Cendre Ash	Eau Water	Cendre Ash
Chiba . .	3.93	0.10	8.38	0.12
Atsubetsu	10.98	0.18	11.11	0.13
Akita . .	10.56	0.12	10.44	0.10
Hyogo .	7.62	0.13	8.21	0.06
Tochigi .	10.41	0.09	11.02	0.05
Shiga . .	7.66	0.12	8.05	0.10
Mie . . .	8.57	0.16	8.92	0.10
Akita . .	13.38	0.11	12.24	0.08
Asahikawa	11.80	0.15	11.74	0.13
Ibaragi .	7.81	0.10	8.01	0.04
Mino . .	11.06	0.20	10.50	0.15
Moyenne / Average		0.13	—	0.09

Common Rice Starch, free from Glutinous Starch.

	Higo	Hiuga	Shikoku	Shonai	Kumamoto	Chiba	Siam	Formosa	Manchuri
Water . .	9.60	8.94	7.80	10.20	7.50	8.93	9.58	7.28	7.37
Ash . . .	0.06	0.09	0.08	0.10	0.06	0.04	0.09	0.09	0.06

From the above results the authors deduce that the ash content of glutinous rice starch is always less than that of common rice starch.

The mineral constituents of starch are K_2O, P_2O_5, CaO and SiO_2; Samec stated that 100 grams of starch ash contain 19.4 g. of SiO_2 and 46.6 g. of P_2O_5 which are abundant in amylopectine and are very scarce in amylose. The amount of these constituents in different kinds of rice starch was determined.

Table II.

Common Rice Starch: Percentages of Total Ash.

	P_2O_5	SiO_2		P_2O_5	SiO_2		P_2O_5	SiO_2
Atsubetsu	13.85	4.24	Akita . .	3.34	29.72	Mie . . .	8.01	5.92
Hyogo . .	8.56	8.82	Asahikawa	6.70	9.21	Kamenoo	22.47	11.66
Higo . .	7.35		Saitama .	6.60	29.52	Etchu . .	4.63	11.66
Saitama .	—	29.01	Kiushu .	—	19.15	Ibaragi .	5.15	17.41
Tochigi .	—	8.22	Higo . .	5.47	21.66	Niigata .	4.13	58.02

Glutinous Rice Starch: Percentages of Total Ash.

	P_2O_5	SiO_2		P_2O_5	SiO_2		P_2O_5	SiO_2
Atsubetsu	16.71	19.67	Kiushu .	1.14	17.61	Shinohara	2.10	51.70
	4.36	—	Mie . . .	5.78	29.51	Ibaragi .	7.57	77.54
Etchu . .	3.21	14.48						

Average of Percentages of P_2O_5 and SiO_2.

	Common rice starch	Glutinous rice starch
P_2O_5	9.26	7.76
SiO_2	18.13	35.79

The average amount of P_2O_5 is greater in common rice starch than in glutinous and the amount of SiO_2 is less. The quantities of the two constituents were not present in any fixed proportions, so that it was supposed that they made no definite compound with the $C_6H_5O_{10}$-radicle in starch.

II. SOME PHYSICO-CHEMICAL PROPERTIES OF STARCH GRANULES.

1. Swelling of Starch Granules.

In the following experiments the authors took 2 g. of air-dried starch prepared by the above method and mixed it with 25 c.c. of solutions of iodine in potassium iodide of different concentrations, such as N/10, N/25, N/50, N/100, N/150; no noticeable difference could be discovered in the degree of swelling.

Table III.

Concentration de la solution I-KI Concentration of I-KI solution	Grains d'amidon de riz commun Common starch granules		Grains d'amidon de riz glutineux Glutinous starch granules	
	Volume observé Observed volume	% de l'augmentation de volume % of increased volume	Volume observé Observed volume	% de l'augmentation de volume % of increased volume
N/10	3.67 c.c.	217	13.66 c.c.	592
N/12	3.45 »	204	12.11 »	535
N/13	—	—	11.75 »	519
N/14	3.08 »	182	10.65 »	470
N/15	2.68 »	164	9.92 »	438
N/20	2.43 »	144	9.17 »	405
N/25	2.15 »	127	4.80 »	181
N/40	2.13 »	126	3.03 »	133
N/50	2.13 »	125	2.54 »	112
N/100	2.11 »	125	2.27 »	104
N/150	1.81 »	110	2.26 »	100
Eau (témoin) Water (control)	1.69 »	100	2.26 »	100

2. Absorption of Iodine by Starch Granules.

One gram of water-free starch was taken in each bottle and to it were added 40 c.c. of iodine water or alcoholic solution of iodine of various concentrations, such as N/200, N/150, N/100, N/75, N/50, N/25, N/15, N/14, N/13, N/12, N/10.

Each bottle was shaken in the shaking apparatus for 30 minutes when the absorption of iodine solution by starch had attained its maximum. The solution in each bottle was transferred to a glass centrifuge tube as completely as possible and centrifuged for 15 minutes, when the clear supernatant liquid was separated from the starch iodide. Five c.c. of the supernatant liquid was titrated with N/10 or N/100 sodium thiosulphate solution. The results obtained from the above experiments are given in the following table where C = concentration of iodine solution at equilibrium; X/M = amount of iodine absorbed by 1 g. starch.

Table IV.

Concentration de la solution d'iode employée pour la réaction / Concentration of I_2 solution used in the reaction	Amidon de riz glutineux Glutinous rice starch				Amidon de riz commun Common rice starch			
	X/M (mg.)	C (mg.)	Log X/M	Log C	X/M	C (mg.)	Log X/M	Log C
N/200	19.2813	6.0888	1.285132	0.784526	24.3552	1.0148	1.38659	0.006384
N/100	36.5328	114.2073	1.562680	1.152500	45.6660	5.0740	1.65969	0.705350
N/75	45.6660	21.3108	1.659594	1.328580	54.7992	12.1776	1.738780	1.085578
N/50	71.0360	30.4440	1.851476	1.483500	74.0804	27.3996	1.867000	1.437750
N/25	169.4716	33.4884	2.229092	1.524894	141.0572	61.9028	2.149406	1.791771
N/20	202.9600	50.7400	2.307412	1.705350	162.3680	91.3320	2.210509	1.960620
N/15	228.3300	106.5540	2.358567	2.027550	202.9600	131.9240	2.307412	2.120306
N/14	228.3300	162.8500	2.358567	2.103290	202.9600	152.2200	2.307412	2.182468
N/13	243.5520	142.0720	2.386590	2.152500	233.4040	152.2200	2.368100	2.182468
N/12	243.5520	172.5160	2.386590	2.236840	243.5520	172.5160	2.386990	2.236840
N/10	262.8332	244.5668	2.419678	2.388406	212.8332	244.5668	2.419678	2.388406

The logarithms representing the degree of absorption of iodine by glutinous rice starch do not fall on one straight line according to Freundlich's absorption formula, but evidently fall along two straight lines which have a markedly different direction from each other.

In the case of common rice starch, though the logarithms seemed to fall almost on one straight line, yet, as in the case of glutinous rice starch, the authors found that they fell along two straight lines which had only a slightly different direction from each other. When the authors used an alcoholic solution of iodine instead of a watery solution, they could plot one straight line, expressing the logarithmic equation of Freundlich's formula, in the case of both kinds of starch.

Constants obtained from the straight lines expressing logarithms of absorption are as follows:

Table V.

Constants	Glutinous rice starch		Common rice starch	
log K . . .	2.03	0.69	1.20	1.39
1/n	11.0/68.5=0.1605	20/26.5=0.7547	27/50.5=0.5347	23/68=0.34

The constants obtained by calculation are as follows:

Table VI.

Glutinous rice starch.

(α) Taking two values for log X/M and log C,

$2.419678 = \log K + 1/n 2.388406$

$2.307412 = \log K + 1/n 1.705350$

$0.112266 = 1/n 0.683056$

$1/n = 0.1643$

$2.419678 = \log K + 0.1643 \times 2.388406$

$K = 106.478$

Common rice starch.

(α) Taking two values for log X/M and log C,

$2.386590 = \log K + 1/n 2.236840$

$2.149406 = \log K + 1/n 1.791711$

$0.237184 = 1/n 0.445129$

$1/n = 0.5528$

$2.386590 = \log K + 0.5528 \times 2.236846$

$K = 15.66$

(β) Taking two values for log X/M and log C,

$$1.562680 = \log K + 1/n1.152500$$
$$1.285132 = \log K + 1/n0.784526$$
$$0.277548 = 1/n0.367974$$
$$1/n = 0.7543$$
$$1.285132 = \log K + 0.9543 \times 0.784526$$
$$K = 493577$$

(β) Taking two values for log X/M and log C,

$$1.869700 = \log K + 1/n1.437750$$
$$1.386590 = \log K + 1/n0.006384$$
$$0.483110 = 1/n1.431366$$
$$1/n = 0.34$$
$$1.869700 = \log K + 0.34 \times 1.437750$$
$$K = 24.04$$

Next, the authors examined the absorption by starch of iodine in watery solution, using different samples; they calculated the constants by the method of least squares to be described later.

Table VII.

	Chiba		Mie		Atsubetsu	
	Common	Glutinous	Common	Glutinous	Common	Glutinous
1/n	0.4406	0.7907	0.4621	0.7452	0.5460	0.7936
K	19.0521	4.7211	25.4965	6.01413	11.3900	4.3936

The results are very similar to those of the first experiment, *i.e.*, K for common rice starch is greater than that for glutinous; with respect to 1/n the reverse was observed. The following experiments were made with alcoholic iodine solution instead of watery solution.

Table VIII.

	Akita		Etchu		Asahikawa	
	Common	Glutinous	Common	Glutinous	Common	Glutinous
1/n	0.5412	0.6666	0.5425	0.6644	0.5344	0.6124
K	0.9192	0.7452	0.8307	0.6863	0.7524	0.7524

The value of K for common rice starch is greater than that for glutinous, while 1/N for the former is less than that for the latter.

3. The Resistance of Starches against Sulphuric Acid.

In order to examine the resistance of glutinous and common rice starches against sulphuric acid, the following experiment was carried out. Two g. of starch were introduced into a bottle and mixed thoroughly with 50 c.c. of water; sulphuric acid of various concentrations (such as 1 c.c. of 1/100 H_2SO_4, 1/10 conc. H_2SO_4, etc.) was added and the mixture was boiled on a water-bath with a long glass tube as a condenser for 2–4 hours. The solution was filtered after the digestion was complete and the remaining precipitate was washed with water till the filtrate gave no acid reaction. The precipitate and the filter paper were then introduced into a drying tube and dried in a water oven till a constant weight was obtained. The results are shown in the following table.

Table IX.

	Residue in % of air-dried substance			
	Rice Starch			
	Glutinous	Common	Glutinous	Common
2 g. Starch + 50 c.c. H_2O+1 c.c. H_2SO_4 (1/100 conc.) boiled for 2 hours . . .	0.7250	0.4600	0.8259	10.6406
2 g. Starch + 50 c.c. H_2O+1 c.c. conc. H_2SO_4 boiled for 2 hours	0.3250	0.7050	0.3702	07.930
2 g. Starch + 50 c.c. H_2O+1 c.c. conc. H_2SO_4 boiled for 4 hours	0.1950	0.4350	0.2221	0.4893
2 g. Starch + 50 c.c. H_2O+1 c.c. conc. H_2SO_4 boiled for 6 hours	0.1950	0.4350	0.2221	0.4893
2 g. Starch + 50 c.c. H_2O+1 c.c. conc. H_2SO_4 boiled for 4 hours	0.1850	0.4300	0.2107	0.4837
2 g. Starch + 50 c.c. H_2O+1 c.c. H_2SO_4 (1/100 conc.) boiled for 2 hours . . .	0.1950	11.3000	0.2178	12.8006
2 g. Starch + 50 c.c. H_2O+1 c.c. H_2SO_4 (1/10) boiled for 2 hours	0.1500	1.0350	0.1615	1.1724
2 g. Starch + 50 c.c. H_2O+5 c.c. H_2SO_4 (1/10) boiled for 2 hours	0.1200	0.7950	0.1340	0.9005
2 g. Starch + 50 c.c. H_2O+ 1 c.c. conc. H_2SO_4 boiled for 2 hours	0.0100	0.6000	0.0782	0.6797

Further experiments were undertaken with different samples. One gram of water-free starch was introduced into a bottle and mixed thoroughly with 50 c.c. of water to which was added 1 c.c. of concentrated sulphuric acid; it was then boiled on the water-bath (98-100°C.) with a long glass tube as a condenser for 2 hours. The solution was filtered after digestion; the remaining precipitate was washed with water till the filtrate gave no acid reaction. The dried precipitate was weighed

and the filtrate neutralised and made up to 100 c.c. The reducing power of a definite quantity of the solution was determined by Bertrand's method. The results obtained are given in the table.

Table X.

	Akita		Etchu		Asahigawa	
	Common rice	Glutinous starch	Common rice	Glutinous starch	Common rice	Glutinous starch
Insoluble residue (mg.)	4.05	1.25	4.80	2.40	6.15	3.80
Insoluble residue (% of starch)	0.405	0.125	0.430	0.240	0.615	0.380
Ratio	100	30.8	100	55.8	100	61.7
Cu in 20 c.c. solution (mg.)	353.113	349.059	356.631	350.274	362.249	358.341
Glucose, calculated	186.069	183.735	187.738	184.316	191.249	189.071
Difference between glucose content of common and glutinous	2.333		3.422		2.178	
Sugar (% of starch)	93.03	91.87	93.86	92.15	95.62	94.53
Difference between common and glutinous	1.16		1.71		1.19	

From the results shown in Tables IX and X, the following conclusions were drawn: (1) after hydrolysis with sulphuric acid common rice starch leaves a greater insoluble residue than glutinous; (2) the hydrolytic products of common rice starch contain a greater quantity of reducing sugar than those of the glutinous variety.

4. Charcoals from Starch Granules.

The authors investigated the difference between the charcoals obtained from common and glutinous rice starches. The difference in the power of adsorbing iodine was observed in the case of charcoals obtained from common and glutinous rice starches. The value of the constant K in the case of common rice starch charcoal was greater than that of glutinous, while $1/n$ of the former was less than that of the latter. The relation of the constants is just the same as that of the adsorption of iodine by starch granules. The experiment was repeated with different samples and the results obtained are here given as well as calculations of the adsorption constants.

Table XI.

Concentration de la solution de iode Concentration of I_2 solution	Charbon d'amidon de riz commun Common rice starch charcoal				Charbon d'amidon de riz glutineux Glutinous rice starch charcoal			
	C (mg.)	X /M (mg.)	log C	log X /M	C (mg.)	X /M (mg.)	log C	log X /M
	1.5816	14.2785	0.20045	1.15470	3.4903	12.3747	0.54287	1.09255
N /100	7.6152	24.1148	0.88168	1.38229	12.3747	19.3553	1.09255	1.28680
N /75	13.9612	28.3667	1.14492	1.45282	17.2929	25.0037	1.23786	1.39800
N /50	32.0473	31.4127	1.50579	1.49711	32.6819	30.3781	1.51430	1.48824
N /25	87.5748	39.3452	1.94238	1.59489	85.9883	40.6144	1.93440	1.60868
N /15	163.7268	47.5950	2.21412	1.67757	159.9192	49.4988	2.20390	1.69460
N /10	266.8493	50.4504	2.42627	1.70286	261.4552	55.8448	2.41740	1.74698
Equations des observations Observation equations	$\log k+1/n(0.20044)-1.15470=0$				$\log k+1/n(0.54283)-1.09255=0$			
	$\log k+1/n(0.88168)-1.38229=0$				$\log k+1/n(1.09255)-1.28680=0$			
	$\log k+1/n(1.14492)-1.45282=0$				$\log k+1/n(1.23786)-1.39800=0$			
	$\log k+1/n(1.50579)-1.49711=0$				$\log k+1/n(1.51430)-1.48824=0$			
	$\log k+1/n(1.94238)-1.59489=0$				$\log k+1/n(1.93444)-1.60868=0$			
	$\log k+1/n(2.21412)-1.67757=0$				$\log k+1/n(2.20390)-1.69460=0$			
	$\log k+1/n(2.42627)-1.70286=0$				$\log k+1/n(2.41740)-1.74698=0$			
	$7\log k+1/n(10.31560)-10.46224=0$				$7\log +1/n(10.94332)-10.31685=0$			
Equations normales Normal equations	$10.31560\log K+1/n(18.95774)-16.31117=0$				$10.94332\log K+1/n(19.75484)-17.04134=0$			

$1/n = 0.1999$ $1/n = 0.3448$

	Common rice starch charcoal		Glutinous rice starch charcoal	
	1 /n	K	1 /n	K
Chiba	0.283	11.9039	0.3095	10.4429
Mie	0.1999	15.4848	0.3448	8.6060
Asahikawa	0.2560	11.6271	0.3108	9.4338

5. Methylation of Starch.

The authors determined the methoxyl group in methyl starch by Zeisel's process as modified by Hewitt and Moore; they found a definite difference between the methoxyl content of glutinous and common rice methyl starches.

Table XII.

% of starch	Akita		Etchu		Asahigawa	
	Common	Glutinous	Common	Glutinous	Common	Glutinous
(1)	2.429	0.832	1.568	0.564	1.277	0.430
(2)	2.464	0.837	1.554	0.561	1.305	0.438
Average. . .	2.446	0.834	1.561	0.562	1.291	0.434
Ratio	100	34.2	100	36.0	100	53.6

The methoxyl group content of glutinous rice starch is less than that of common; the value of the former is 34 to 36 per cent of the value of the latter.

6. Acetylation of Starch.

The method of acetylation of cellulose and starch has been reported by many authors, such as Boeseken, Randall, Meyer and Lassar-Cohn; acetic anhydride and $ZnCl_2$ were used in these experiments.

(a) *Content of Acetyl Group in Acetyl starch.*

The acetyl group of acetyl starch was determined by Wenzel's method; the following results were obtained.

Table XIII.

	Akita	Etchu	Hyogo	Chiba	Asahikawa
	Com. Gluti.	Com. Gluti.	Com. Gluti.	Com. Gluti.	Com. Gluti.
% of starch . . .	58.46 57.47	56.98 54.44	57.97 57.08	57.77 55.99	54.50 53 71
Ratio.	100 : 98.30	100 : 95.89	100 : 98.46	100 : 96.91	100 : 98.91

The acetyl group content of common rice acetyl starch is always greater than that of glutinous rice acetylstarch. This is due to the greater number of OH groups in the former.

(b) *Melting-point and Specific Rotatory Power of Acetyl starch.*

The melting-points of the acetyl starches were determined by the ordinary method with the following results.

Table XIV.

	Com.	Gluti.	Com.	Gluti.	Com.	Gluti.	Com.	Gluti.	Com.	Gluti
Melting-point	157–8	149	164	148–150	158–9	151	158–160	150–2	159–160	149

The melting-point of common rice acetyl starch is always higher than that of glutinous.

The specific rotatory power of acetyl starch dissolved in pyridin was determined by Haensch-Schmidt's half-shadow polariscope.

Table XV.

	Acétyl-amidon de riz commun Common rice acetyl starch	Acétyl-amidon de riz glutineux Glutinous rice acetyl starch
Akita . .	$[\alpha]_D^{15} = \frac{-7.1 \times 0.346 \times 25}{0.2 \times 2} = +156.04$	$[\alpha]_D^{15} = \frac{-6.9 \times 0.346 \times 25}{0.2 \times 2} = +148.78$
Etchu . .	$[\alpha]_D^{15} = \frac{-7.05 \times 0.346 \times 25}{0.2 \times 2} = +152.46$	$[\alpha]_D^{15} = \frac{-6.7 \times 0.346 \times 25}{0.2 \times 2} = +144.02$
Asahikawa	$[\alpha]_D^{15} = \frac{-6.8 \times 0.346 \times 25}{0.2 \times 2} = +147.05$	$[\alpha]_D^{15} = \frac{-5.8 \times 0.346 \times 25}{0.2 \times 2} = +125.42$
Hyogo . .	$[\alpha]_D^{15} = \frac{-7.0 \times 0.346 \times 25}{0.2 \times 2} = +151.37$	$[\alpha]_D^{15} = \frac{-6.6 \times 0.346 \times 25}{0.2 \times 2} = +142.73$
Chiba . .	$[\alpha]_D^{15} = \frac{-3.6 \times 0.346 \times 25}{0.1 \times 2} = +160.89$	$[\alpha]_D^{15} = \frac{-6.5 \times 0.346 \times 25}{0.2 \times 2} = +140.56$

7. Heat of Combustion of Starch.

The heat of combustion of starch averages 4.18 calories, but it is not precisely the same in all kinds of starch. The heat of combustion of pure common and glutinous starches was determined by means of Atwater and Benedict's bomb-calorimeter with the following results.

Table XVI.

	Etchu		Akita		Chiba	
	Common	Glutinous	Common	Glutinous	Common	Glutinous
Calories per 1 g.	4117.8	4033.0	4109.3	4033.3	4018.3	3998.4
	Hyogo		Asahikawa		Atsubetsu	
	Common	Glutinous	Common	Glutinous	Common	Glutinous
Calories per 1 g.	4064.1	4059.7	4199.0	4033.4		3893.3

The heat of combustion of common rice starch is greater than that of glutinous.

III. STARCH SOLUTION AND IODINE.

A great deal of discussion has taken place concerning the nature of the reaction between starch and iodine.

Explanations have been sought on the lines of the theory of colloidal solution, but it is outside the scope of the present work to discuss this theory. The authors have made a study of other work concerned with the differences between common

and glutinous rice starch. As is well known, glutinous rice starch gives a red colour with iodine, whereas common rice starch gives a blue colour. The colour reaction of glutinous rice starch has been investigated by Tanaka, who has denied Dafert's erythrodextrine theory, Atkinson's albuminoid theory and Shimoyama's amylodextrine theory and concluded that the red colour reaction of glutinous rice starch with iodine is a characteristic property of the starch granule itself. He gave no explanation of this characteristic property, therefore the following experiments were undertaken to throw further light on it.

1. Colour Reaction of Pseudo-solution of Starch with Iodine.

The colour of a pseudo-solution of starch with iodine varies according to the ratio of the absorbed to the remaining quantity of iodine. The following experiments were undertaken to show how this colour may be changed by altering the concentration of iodine in the starch solution. The authors took 5 c.c. of starch solution of different concentrations and added different quantities of a solution of iodine in potassium iodide. (The iodine solution was prepared by mixing 2 g. of iodine, 6 g. of potassium iodide and 100 c.c. of water.) Each mixture was then diluted to the same volume and the resulting colours were observed. In the following table, "D" expresses the original concentration of iodine solution.

Table XVII.

Iodine solution c.c.	Common rice starch solution			
	0.05%	0.1%	0.2%	0.5%
0.1 D/4	blue	blue	blue	blue
0.1 D/2	brownish-blue	blue	blue	blue
0.5 D/2	brown	bluish-green	blue	blue
1.0 D/2	greenish-brown	brownish-green	blue	blue
1.0 D	reddish-brown	greenish-brown	brownish-green	greenish-blue
	Glutinous rice starch solution			
	0.05%	0.1%	0.2%	0.5%
0.1 D/4	reddish-purple	violet-purple	light purple	pink
0.1 D/2	brown	purple	purple	purple
0.5 D/2	brown	reddish-brown	brownish-purple	reddish-purple
0.0 D/2	brown	brown	reddish-brown	purple
1.0 D	—	—	—	—

The same brown or reddish-brown colour was observed in the two kinds of starch solution, though it did not appear with the same concentration of iodine. In the glutinous rice starch solution, the reddish-brown colour appeared more readily

with dilute solutions of iodine than in the case of common rice starch. This may be due to the fact that in glutinous rice starch solutions the quantity of iodine remaining unabsorbed was greater than in the case of common rice starch.

Next, the authors set out to examine the iodine-starch colour reaction when the starch content was in excess of the iodine content. For each of these experiments the authors took 5 c.c. of a 0.5% starch solution and added to each the following different small quantities of iodine solution.

Table XVIII.

No. of experiment	Concentration of iodine solution	c.c. of iodine solution added	Colour of common rice starch solution	Colour of glurinous rice starch solution
1	N/4000	0.4	no colour	no colour
2	N/4000	0.3	light purple	no colour
3	N/4000	1.5	deep blue	light blue
4	N/2000	1.0	deep blue	light blue
5	N/2000	2.0	deep blue	purple
6	N/2000	3.0	deep blue	red

Almost the same blue colour was observed in both common and glutinous rice starch solutions. With glutinous rice starch the blue colour appeared when the iodine content was in excess of the starch content, and with common rice starch the reddish-brown colour appeared when the starch content was in excess of the iodine content.

The intensity of the above colours in the two starch solutions was compared by means of Dubosque's colourimeter.

Table XIX.

No. of above experiment	Colour of solution	Thickness of common rice starch solution (mm.)	Thickness of glutinous rice starch solution (mm.)	% of colour intensity
3	blue	3.6	12.4	29.03
4	blue	2.0	11.1	18.01
7	purple	11.0	7.0	63.63

In experiment No. 7, different quantities of iodine solution were added to the two starch solutions, *i.e.*, 0.8 c.c. to common rice starch solution and 4.6 c.c. to glutinous rice starch solution. This was because the purple colour of glutinous rice starch solution was more intense than that of common rice starch solution, though the blue colour in experiments Nos. 3 and 4 was more intense in common than in glutinous rice starch.

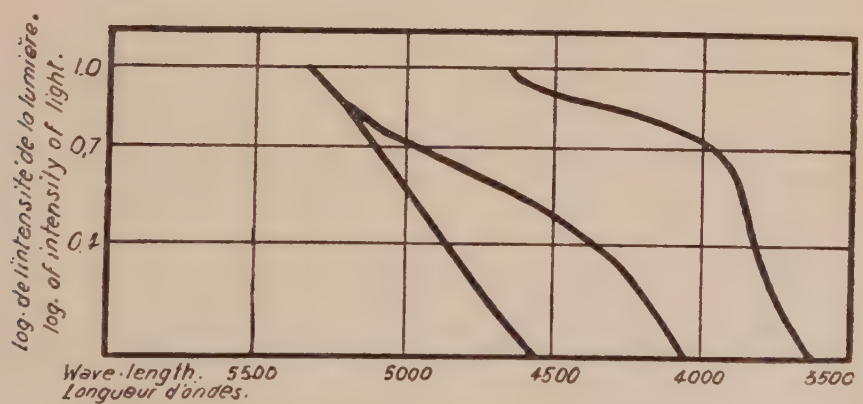
It was necessary to investigate further this colour reaction and the authors decided to examine it spectroscopically. First, they examined three iodine-starch solutions of different colours — brown, green and blue — to determine the variation

in the position of the absorption bands. They took 5 c.c. of common rice starch solution and mixed with it the following quantities of the iodine-potassium-iodide solution used in the previous investigations. A quartz-cell of 10 mm. thickness was filled with the solution to be tested; the illuminating source was an electric lamp of 100 candle-power and the intensity was measured with a photometer. The wave-lengths of the boundary lines of the absorption bands were measured on photographic plates, and are given in the following table.

Table XX.

Exposure = 60 sec. . . Starch solution . . . Iodine solution	brown colour 5 c.c. of 0.05% 1 c.c. of ½ conc.	green colour 5 c.c. of 0.1% 1 c.c. of ½ conc.	blue colour 5 c.c. of 0.1% 1 c.c. of ¼ conc.
Spector of photometer	Wave-length of boundary line	Wave-length of boundary line	Wave-length of boundary line
1.0	4550	4105	3660
0.4	4850	4345	3835
0.7	5100	4990	3965
0.0	5325	5325	4650

The authors traced three curves, plotting the logarithm of intensity of light on the ordinate and the wave-length of the boundary lines of the absorption bands on the abscissa.



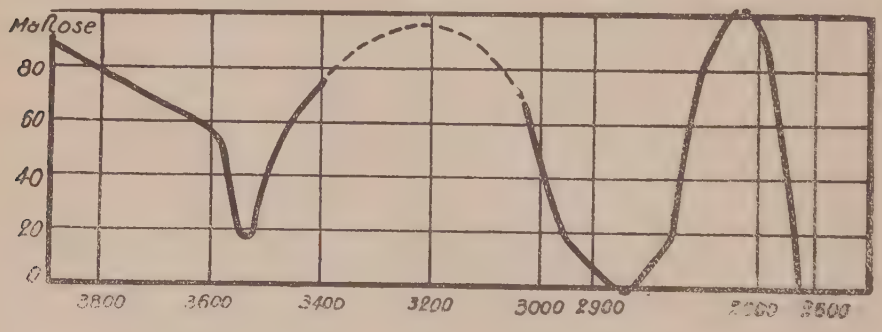
From these three curves it was seen that the absorption of the spectrum of brown was greater than that of blue. The next stage was to compare the absorption of the colour of common and glutinous rice starch in the same concentration of iodine solution. Therefore the authors examined a solution of 10 mm. thickness by means of a quartz-spectroscope (D.I., Adam Hilgard, made in London), using a hydrogen tube of 7 cm. capillary, charging *circa* 15,000 volts A.C. and took photographs with six-minute exposures.

Before comparing the colour reactions of the two starches, the authors examined the change in the absorption bands of the spectrum of solutions of different colours produced by adding iodine to soluble starch during digestion by Takadiastase. They took 30 c.c. of soluble starch solution and, after adding 2 c.c. of 1 % Takadiastase at 45° C., took out samples at different periods and examined them spectroscopically; the following results were obtained:

Table XXI.

No.	Minutes of digestion	Colour with iodine solution	Wave length of boundary lines of absorption bands				
			(3700–3300)		(3100–2600)		2600
1	0	blue	—	—	2824	2835	2535
2	20	reddish-violet	3555	3545	2965	2745	2545
3	40	brownish-violet	3555	3525	2975	2745	2555
4	60	reddish-brown	3570	3430	3020	2720	2560
5	80	brown	3610	3395	3050	2700	2560
6	maltose	brown	3810	—	—	2650	2520

The authors traced the following curves, plotting minutes of digestion on the ordinate and wave-length on the abscissa.



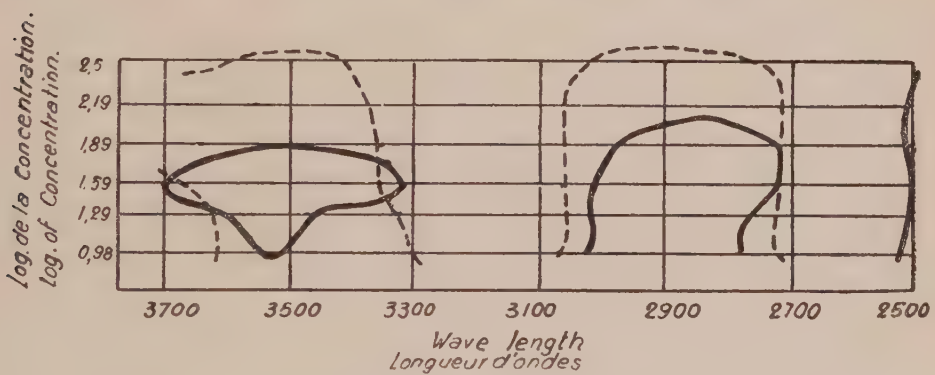
During the dextrination of starch, the spectrum of the solution after the addition of iodine showed different types of absorption bands; the first was in the region 3750-3300, the second was in the region 3100-2600, and the third in the region 2600. The blue colour caused by the predominance of starch in the solution showed a greater transparency in the spectrum than the violet or brown colour, which showed a wider absorption band.

Experiments were performed to find out the exact difference between the absorption bands of mixtures of common and glutinous rice starches with iodine. All photographs were taken with a six-minute exposure through 10 mm. of liquid, illuminated by a hydrogen tube of 7 cm. capillary, charging *circa* 15,000 volts A.C. The authors prepared the following starch solutions of different concentrations and 30 c.c. of each were mixed with 2 c.c. of 1% iodine solution; the following results were obtained.

Table XXII

Concentratio of starch solution	Wave-length of boundary lines of absorption bands	
	In common rice starch	In glutinous rice starch
0.0312 %	— — — — 2510	3600-3420 3035-2755 2500
0.0156 %	— — — — 2490	3750-3320 3085-2705 2505
0.0078 %	3520 3000 - 2770 2505	3750-3320 3085-2705 2505
0.0039 %	3725-3330 3085-2775 2507	3680-3340 3070-2705 2710
0.00199 %	3590-3460 3025-2780 2500	3650-3350 3070-2715 2500
0.00097 %	— 3520 3010-2790 2490	3650-3360 3050-2720 2500

The authors traced the following curves plotting the logarithm of concentration of starch solution on the ordinate and the wave-length on the abscissa.



The authors found three different absorption bands in each kind of starch. The first was in the region 3800-3200, the second in the region 3000-2700 and the third in the region 2500. In the case of common rice starch solution, the first and second bands were not observed with the higher concentrations of starch, while in the case of glutinous they were clearly observed. If this difference between the two kinds of starch is considered and compared with the former experimental results, it may be concluded that the absorption of iodine by common rice starch is greater than that of glutinous — that is to say, when mixed with iodine the common rice-starch solution contains less free iodine than glutinous — starch solution.

2. Decoloration of Iodine-Starch Solutions by X-rays.

The authors set out to determine the difference between the degree of decoloration by X-rays of common and glutinous rice iodine-starch mixtures. They prepared similar blue solutions with common and glutinous rice starch by the following means. Five c.c. of 0.5% starch solution was poured into a glass tube of 12 mm. diameter and mixed with 1.5 c.c. of N /4000 iodine potassium iodide solution and exposed

to X-rays from a tube of 5 Benoist units of hardness, consuming 2 milliamps of alternating current at about 35,000 volts. The light-blue solution of glutinous rice starch was bleached after an exposure of about ten minutes, while the deep-blue colour of common rice-starch solution still remained; after exposure for 45 minutes, this colour entirely disappeared.

Next, the authors compared the resistance to X-rays of the colour of iodine with that of iodine-starch mixture. In this experiment they took 5 c.c. of 0.5% starch solution, added 1 c.c. of N/600 iodine solution and compared it with iodine solution without starch. After 45 minutes exposure the iodine solution was completely bleached, while the iodine-starch solution still retained its colour. It is a very curious fact that glutinous rice starch solution changes its colour from red to blue under the influence of X-rays, though this blue colour is far lighter than that of common rice-starch solution and fades away, while that of common starch solution still remains. It is apparent that the excess of iodine in glutinous rice-starch solution is quickly bleached and the remaining iodine-starch solution shows a blue colour like that of common rice starch. The bleaching of the colour of common rice-starch solution is very difficult because it contains a large quantity of iodine-starch mixture which is more resistant to X-rays than free iodine.

IV. SOME COLLOIDAL PROPERTIES OF STARCH SOLUTIONS

1. The Viscosity of Starch Solutions.

Glutinous rice is used in the preparation of "Mochi", a kind of Japanese food, characterised by its high viscosity. In order to determine whether this viscosity is due to the high viscosity of the glutinous rice starch employed in its preparation, the authors carried out the following experiments with glutinous and common rice starches.

One hundred c.c. of 0.25, 0.5, 0.7 and 1% starch solutions were taken, and their viscosities were determined by a MacMichael viscosimeter, at 16.5°C. From the average values of three samples the authors calculated the following relative viscosities (water = 1):

Table XXIII.

	Concentration of starch solution			
	0.25 %	0.5 %	0.7 %	1 %
Common rice starch. . . .	2.25	2.50	2.78	2.93
Glutinous rice starch. . . .	2.43	3.78	4.27	10.57

The viscosity of a starch solution differs according to the method by which it is prepared. The following samples were prepared by the authors. Starch was made into a paste with water by heating it for four minutes on a boiling-water bath, and

the paste was then made up to 100 c.c. and boiled for 20 or 40 minutes in boiling water at 98 to 100° C. The viscosity of the resulting starch solution was determined by MacMichael's viscosimeter at 15°C. and the following values for the specific viscosity were obtained.

Table XXIV.

	Bouilli pendant 20 minutes Boiled for 20 minutes			Bouilli pendant 40 minutes Boilled for 40 minutes		
Common rice starch	1%	1.5%	2%	1%	1.5%	2%
Common rice:						
Sai ama	18.5	38.0	91.0	18.5	37.5	98.0
Tochigi.	29.0	78.0	270.0	25.5	75.0	250.0
Higo	21.0	47.5	138.0	20.0	51.0	147.0
Hiuga	24.5	63.5	211.5	25.0	70.0	190.0
Shikoku	26.0	82.5	137.5	26.0	82.0	290.0
Niigata.	23.5	45.5	122.0	22.0	48.0	185.0
Shonai	19.0	37.0	91.0	17.0	43.0	112.0
Chiba	26.5	66.0	201.0	23.0	62.0	192.0
Mie	22.0	52.0	145.5	22.0	56.0	171.0
Hyogo	25.5	61.0	175.0	23.0	62.0	199.0
Ibaragi.	21.0	46.0	135.0	22.0	55.0	131.0

Glutinous rice starch (boiled for 20 minutes).	Etchu	Mie	Hyogo	Atsubetsu	Ibaragi
0.5 %	17.0	16.5	16.0	16.5	15.5
0.75 %	30.5	31.5	23.0	29.0	35.5
1.0 %	56.0	47.0	45.0	44.0	64.0
1.25 %	99.0	90.5	81.0	79.5	127.5

The authors observed a remarkable difference between the viscosity of glutinous and of common rice-starch solution. The viscosity of the former was always twice or three times as great as that of the latter, and it varied with the different samples of rice. Further investigation was undertaken to determine the influence that the duration of boiling of a starch solution exerted on the viscosity. The viscosity of starch solutions heated for the following times on a water bath at 98 to 100° C. was measured with a MacMichael viscosimeter at 15° C.

Table XXV.

Amidon de riz glutineux Glutinous rice starch	Concentration	3 minutes	7 minutes	15 minutes	30 minutes	60 minutes
Etchu. . .	1.0%	7.1	8.4	8.4	8.3	8.5
Akita . . .	1.0%	8.2	8.9	8.9	8.9	8.9
Asahikawa.	1.0%	6.3	6.2	7.4	7.2	7.5
Etchu . . .	1.5%	33.4	33.2	39.4	39.8	32.5
Akita . . .	1.5%	38.7	39.7	45.7	46.5	44.5
Asahikawa.	1.5%	24.2	25.9	28.5	20.4	19.2

The viscosity of glutinous rice starch increased proportionally to the length of time of boiling, and reached a maximum at a definite time, after which it decreased. The length of time of boiling needed to produce the maximum viscosity varied in the different kinds of glutinous rice-starch used.

Ten c.c. of 1% or 2% starch solution were introduced into an Ostwald's viscosimeter and cooled to 20° C. The time (t) required for the outflow of the starch solution was noted and compared with that of water (t_0) at 20° C. The ratio t/t_0 was used in comparing the viscosity of glutinous and common rice starches and the results are given in the following table.

Table XXVI.

Following rice	Glutinous rice starch (1%)	Common rice starch (1%)	Glutinous rice starch (2%)	Common rice starch (2%)
t	21 1/5″	14″	25 3/5″	17 3/5″
t_0	8 3/5″	8 3/5″	8 3/5″	8 3/5″
t/t_0	2.465	1.628	1.4605	2.407

The experiment was undertaken with different samples and their specific viscosity was calculated.

Table XXVII.

	Chiba		Mie		Atsubetsu	
	Common	Glutinous	Common	Glutinous	Common	Glutinous
0.5 %	1.226	1.797	1.065	1.725	1.114	1.543
1.0 %	1.669	4.549	1.602	4.029	1.514	3.364
1.5 %	1.797	18.075	2.239	13.696	1.879	11.421

The viscosity of glutinous rice-starch solution is greater than that of common rice-starch solution and the difference is more marked with higher concentrations of starch in the pastes.

3. Determination of Amylose and Amylopectine in Starches.

The authors determined the difference between the amylose and amylopectin contents of common and glutinous rice starch respectively. Using Ling and Nangis' method they obtained the following results:

Table XXVIII.

	Amylopectin		Amylose	
	Common rice starch	Glutinous rice starch	Common rice starch	Glutinous rice starch
Kyushu	80.98	28.78	19.02	71.22
Ibaragi	81.09	28.58	18.91	71.47
Atsubetsu . . .	72.49	20.68	27.68	79.32
Mie	72.00	25.49	28.00	74.51

V. PHYSICO-CHEMICAL PROPERTIES OF SOLUBLE STARCHES.

1. Preparation and Composition of Soluble Starch.

The soluble starch was prepared as follows: 500 g. of starch were soaked in 2 litres of 7.5% HCl solution, shaken many times a day and kept for 10 days at 20° C. The soaked starch was washed with water until the wash water showed no chlorine reaction and it was then washed with 70% alcohol and poured on to a silk cloth placed on a filter. The starch was washed again with pure alcohol and ether and dried for two days at 40° C. The amount of water and mineral substances in the sample was determined.

Table XXIX.

	Common rice soluble starch		Glutinous rice soluble starch	
	(1)	(2)	(1)	(2)
Moisture . . .	7.67	12.87	5.96	11.98
Ash	0.038	0.045	0.024	0.028

The above operation involves a process of demineralisation. There was less mineral matter is glutinous rice soluble starch than in common soluble starch.

2. Viscosity of Soluble Starch Solutions.

The viscosity of soluble starch solutions differed greatly from that of the original starch solutions. The authors determined the viscosity of common and glutinous rice soluble starch solution with Ostwald's viscosimeter at 15° C. Their specific viscosity is shown in the following table.

Table XXX.

	Common rice soluble-starch		Glutinous rice soluble starch	
	(1)	(2)	(1)	(2)
1.0 %	1.3420	1.3204	1.1316	1.1401
1.5 %	1.5296	1.4694	1.2431	1.3707
2.0 %	1.6554	1.5712	1.4886	1.5189

The viscosity of glutinous rice soluble starch solution was always lower than that of common; it was quite different from that of the original.

3. Alkali Combination with Soluble Starches.

0.5 g. of soluble starch was dissolved in 200 c.c. of 10% NaOH solution and precipitated by the addition of 30 c.c. of 95% alcohol. The supernatant alcohol containing the excess of alkali was poured off and the precipitate was dissolved in 10 c.c. of water and re-precipitated. The manipulation was repeated about seven times and, when the alcohol showed no alkaline reaction, the precipitate was removed and dried in a sulphuric acid desiccator. The ash content of glutinous rice alkali soluble starch was less than that of common — 0.37 per cent in the former and 0.83 per cent in the latter — therefore glutinous rice soluble starch combined with less alkali than did the common. The glutinous rice alkali soluble starch dissolved easily as a 1% solution, while the common starch formed a saturated solution at 0.82 per cent.

4. Precipitation of Alkali Soluble Starch with Alcohol and Acetic Acid.

When soluble starch was dissolved in alkali solution, the amount precipitated with alcohol became steadily less with the lapse of time. Five g. of soluble starch were mixed with 100 c.c. of 10% NaOH solution and shaken for two hours. After different intervals of time a definite quantity of this mixture was mixed with the same volume of 95% alcohol and the precipitate was collected on a filter, dried and weighed.

Table XXXI.

	After 2 hours	Difference	After 48 hours	Difference	After 96 hours
Glutinous (%) .	82.09	3.82	78.17	3.82	74.25
Common (%) .	99.84	4.09	45.75	4.73	91.02

The alcohol precipitate of glutinous rice alkali soluble starch was less than that of common.

When alkali soluble starch was precipitated by the addition of acetic acid, the amount of precipitate varied in the different kinds of soluble starch. 0.5 g. of soluble starch was dissolved in 5 c.c. of 10% NaOH solution and 20 c.c. of water were added; the solution was then neutralised with acetic acid. In the case of common rice soluble starch solution, the precipitate corresponded to 13.87 to 17.44 per cent of the original starch, while in glutinous rice soluble starch solution no precipitate was formed.

13.

BIOCHEMICAL STUDIES OF RICE.

Part I. Oxidase.

By Taro Higuchi

(From the Imperial State Institute for Nutrition Tokyo).

Introduction.

I have analysed samples of many varieties of rice from time to time during the last two years, but have found no special changes in their chemical composition due to the length of time they have been kept. But I have found a great change in their oxidising power; the activity of the oxidising enzyme (oxidase) gradually diminishes from the time the rice is harvested, and during the following year it deteriorates rapidly. It is a well-known fact that there is a distinct difference in the taste of old and new rice, but no one has yet made a quantitative measurement of the relative activity of the ferments.

About 200 samples of unpolished rice and about 80 samples of polished rice were collected from all over Japan, including Chosen, Formosa, Hokkaido and Manchuria. These rices were harvested between the years 1919 and 1923. The samples were dried in a desiccator over calcium chloride for a few days and then kept in glass vessels till required; a sample was kept in the desiccator for use in the contrasting experiment.

I. Qualitative Experiments with Rice-Oxidases.

Three oxidising ferments were investigated — oxidase, peroxidase and catalase. To test the reaction of each, unpolished- and polished-rice flour was extracted and the reagents were added to the flour. The experiments were performed in April 1923; I used " new rice ", harvested in 1922, and " old rice ", harvested in 1921.

The results are shown in Table I.

Table I. — The Reactions of Oxidases of Rice.

Reagents	Colour of reaction	Unpol. rice (new)	Unpol. rice (old)	Pol. rice (new)	Pol. rice (old)
10% guaiac tincture . . .	blue	++	+	+	—
10% guaiac tincture and hydrogen peroxide . . .	deep blue	++	+	+	+
1% guaiacol	red brown	+	—	—	—
1% guaiacol, hydrogen peroxide	deep red brown	+ ++	++	++	+
1% hydrogen peroxide . .	oxygen gas	++++	+	+++	+
α-naphthol, Na_2CO_3, paraphenylendiamin	blue	++	—	+	—
0.05% tyrosin (0.05% Na_2CO_3 sol.)	black	—	—	—	—
10% hydroquinone	red brown	+	—	—	—
10% hydroquinone, hydrogen peroxide	deep red brown	++ +	++	++	—
10% pyrogallol	yellow	+	—	—	—
10% pyrogallol, hydrogen peroxide.	reddish yellow	+ +	—	+	—
1% paraphenylendiamin .	dark brown	+	—	—	—
1% paraphenylendiamin, hydrogen peroxide . . .	blackish violet	+ +	—	+	—
1% α-naphthol (5% alcohol sol.)	lilac	+	—	—	—
1% α-naphthol, hydrogen peroxide.	deep lilac	+	—	+	—
1% benzidin (50% alcohol sol.)	blue	+	—	—	—
1% benzidin, hydrogen peroxide	deep blue	+	—	+	—
1% paraphenylendiamin hydroxide	green	+	—	—	—
1% paraphenylendiamin hydroxide, hydrogen peroxide	deep green	+	—	+	—
2% pyrogallol, 2% paraphenylendiamin	dark brown	+	—	—	—
1% guaiacol, 2% paraphenylendiamin	reddish brown	+	—	—	—
1% paraphenylendiamin, guaiacol, hydrogen peroxide	violet	++++	+	+++	+

Explanation of Table I.

(1) Oxidase gave a weak reaction.

(2) Peroxidase gave a very strong reaction.

(3) Catalase gave a very strong reaction, that is, large quantities of oxygen were liberated when hydrogen peroxide was mixed with the flour.

(4) Unpolished rice always gave a stronger reaction than polished rice.

(5) New rice always gave a stronger reaction than old rice.

(6) The reactions with paraphenylendiamin, guaiacol and hydrogen peroxide were stronger and more rapid than the other reactions.

New rice has a pleasanter taste and seems to be more nourishing than old rice; in fact, because most people prefer new rice, its price is always higher than that of old rice. Till now there has been no chemical method by which one could distinguish the age of rice quickly. Since a coloured oxidation product is formed by the peroxidase, this reaction is suitable for testing the age of rice. I have found a rapid method of distinguishing the year in which a sample of rice was harvested.

A method employing guaiacol and hydrogen peroxide was used by Aso. A modification which is simpler and more accurate is as follows:

Method of Distinguishing the Age of Rice (Higuchi's Method).

To about 1 to 2 grams (about 100 rice-grains) of polished or unpolished rice are added the following reagents:

(1)	Paraphenylendiamin 1% solution	5 cc.
(2)	Guaiacol 1% solution	10 cc.
(3)	Hydrogen peroxide 1% solution	0.2 cc.

The outer layer, or silver skin, and the embryo of new unpolished rice, and the vertical score or longitudinal notch and embryo of new polished rice, become a deep purple colour, while these parts in the case of old rice are not coloured.

The reaction occurs in 1 to 3 minutes.

The colour diminishes proportionally to the length of time of preservation of the rice and to the grade of polishing.

We can distinguish the grade of polishing by comparing the colour with that of unpolished rice of the same age.

Table II shows the diminution of the depth of the colour according to the length of time of preservation of the rice and to the grade of polishing.

Table II. — The Change of the Deepness of the Colour of Rice by the Reagents.

Time measured after the harvest		Unpolished rice	Polished rice
One month	November	++++++	+++++
Two months	December	++++++	+++++
Three months	January	++++++	+++++
Four months	February	+++++	++++
Five months	March	+++++	+++
Six months	April	+++++	+++
Seven months	May	++++	++
Eight months	June	++++	--
Nine months	July	+++	—
Ten months	August	++	—
Eleven months	September	+	—
Twelve months	October	+ or —	—

II. Quantitative Experiments with Rice-Oxidases.

It is important to measure quantitatively the decrease in this oxidising reaction. The peroxidase of rice gives the strongest of the oxidase reactions. The pyrogallol method can be used to demonstrate it, but it is not a simple method. The determination of the activity of the catalase is very simple and accurate. Therefore, if the catalase and peroxidase reactions run parallel with each other, the catalase reaction can be used for the determination of the oxidising power of rice.

Quantitative Method of Determining the Activity of the Peroxidase of Rice.

To 10 grams of unpolished-rice flour are added 50 cc. of 2% pyrogallol solution and 10 cc. of 1% hydrogen-peroxide solution. The mixture is kept for 24 hours at a temperature of 25° C. Pyrogallol is oxidised by the peroxidase to purpurogallin.

$$\underset{\text{pyrogallol}}{C_6H_3(OH)_3} \longrightarrow OHC_6H_5\begin{matrix}O.OC_6H_3(OH)_2\\O.OC_6H_3(OH)_2\end{matrix}$$
purpurogallin

Quantitative Method of Determining the Activity of the Catalase of Rice (Higuchi's Method).

A suitable method for the quantitative determination of catalase was devised after careful investigation into the speed, optimum temperature and time required for the reaction. 500 grains of rice (unpolished or polished) are powdered and 500 cc. of water are added; the mixture is then filtered. To 25 cc. of the filtrate are added 10 cc. of 0.5% neutral hydrogen peroxide, and the mixture is kept at 25° C for one hour. After that, 50 cc. of sulphuric acid (1: 4) are added and the residual quantity of hydrogen peroxide is determined by titration with N/10 potassium permanganate

solution. The percentage of hydrogen peroxide decomposed by the catalase is then calculated. The formulæ for the reaction and the calculation are as follows:

$$2KMnO_4 + 5H_2O_2 + 4H_2SO_4 = 2KHSO_4 + 2MnSO_4 + 8H_2O + 5O_2$$

$$1000\text{ cc. } 1/1NKMnO_4 = \frac{H_2O_2}{2} = \frac{34.016}{2} = 17.008\text{ gm. } H_2O_2$$

$$1000\text{ cc. } \frac{N}{10}\ KMnO_4 = 1.7008\text{ gm. } H_2O_2$$

$$1\text{ cc. } \frac{N}{10}\ KMnO_4 = 0.0017008\text{ gm. } H_2O_2 = 1.7008\text{ mg. } H_2O_2$$

$$2.95\text{ cc. } \frac{N}{10}\ KMnO_4 = 0.00501736\text{ gm. } H_2O_2$$

$$= H_2O_2\ 1\text{ cc. } (0.5\%)$$

$$= 5.01736\text{ mg. } H_2O_2$$

Table III shows the comparison of the activities of the peroxidase and the catalase of rice by using the methods described above.

Table III. — The Comparison of the Activities of the Peroxidase and Catalase of Rice.

Variété de riz Variety of rice	Localité Locality	Année de la récolte The year harvested	Catalase Décomposition de H^2O^2 en % Decomposed % of H_2O_2	Peroxydase Peroxidase Purprogalline crist. (gr.) Purprogallin crystal (grm.)
Akage	Hokkaido . . .	1923	75.59	0.3918
Shinriki	Kumamoto . . .	1923	50.68	0.3472
Chusei-to . . .	Hiroshima . . .	1923	50.17	0.2629
Kumeno-o . . .	Akita.	1923	49.66	0.2421
Togo I.	Fukushima . . .	1923	47.63	0 2163
Hayashinriki . .	Chōsen	1923	43.89	0.2097
Sekitori	Gumma.	1923	42.37	0.1940
Togo II. . . .	Fukushima . . .	1922	26.10	0.0650
Chusei-to . . .	Hiroshima . . .	1922	33.39	0.1423
Akage	Hokkaido . . .	1922	20.51	0.0224
Shinriki	Kumamoto . . .	1922	6.61	+
Kumeno-o . . .	Akita.	1922	15.25	+
Sekitori	Gumma.	1921	15.09	+
Akage	Hokkaido . . .	1921	15.95	+
Chusei-to . . .	Hiroshima . . .	1921	14.58	+

It was found, as is seen in Table III, that the catalase and peroxidase reactions run parallel. Employing the catalase reaction, the whole series of samples were then tested. First I determined the amount of catalase in samples sent to me from all

over Japan. The experiments were performed between December and February 1924, as the activity of catalase is relatively constant during these months.

Table IV shows the activity of catalase from rices harvested in 1923, Table V shows that from rices harvested in 1922, Table VI shows that from rices harvested in 1921, and Table VII shows that from rices harvested in 1920 and 1919.

Table IV. — The Activity of Catalase of the Rices which were harvested 1923.

Variétés de riz The varieties of rice	Lieu de production The place of production	Date de l'ensemencement The time of sowing	Date de la récolte The time of harvest	Sol. $\frac{N}{10}$ de $KMnO_4$ cc. $\frac{N}{10}KMnO_4$ titrated cc.	Décomposition de H_2O_2 en % Decomposed % of H_2O_2	Poids de 1.000 grains de riz Weight of 1,000 rice grains
Aikoku	Chiba-ken	Avr. 29 April	Oct. 26	6.90	76.61	24 085
Akage	Hokkaido	Mai 3 May	Sept. 28	7.20	75.59	20.937
Yasumura	Saitama-ken	Mai 13 May	Oct. 20	8.00	72.88	22.570
Bōzu-gogō	Hokkaido	Mai 14 May	Oct. 3	8.05	72.71	23.220
Shinriki	Okayama-ken	Mai 10 May	Nov. 10	8.85	70.00	22.638
Kagawashinriki	Kagowa-ken	Avr. 30 April	Nov. 10	9.05	69.32	24.356
Ō-mi	Saitama-ken	Mai 13 May	Nov. 1	10.05	64.41	18.645
Shinshinriki	Hyogo-ken	Avr. 21 April	Nov. 10.	12.45	57.80	26.130
Dōgo-chūto	Elùme-ken	Mai 20 May	Oct. 25	13.30	54.91	25.145
Banseishinriki	Kumamoto-ken	Mai 5 May	Oct. 15	13.30	54.91	22.693
Banseishinriki	Wakayama-ken	Mai 9 May	Nov. 5	13.80	53.22	24.775
Aikoku	Ōsaka-fu	Mai 10 May	Oct. 7	13.95	52.71	22.126
Toyokuni	Akita-ken	Avr. 20 April	Sept. 18	14.50	50.85	24.383
Shinriki	Kumamoto-ken	Mai 14 May	Oct. 23	14.55	50.68	22.206
Chusei-to	Hiroshima-ken	Avr. 30 April	Nov. 5	14.70	50.17	23.898
Kameno-o	Akita-ken	Avr. 30 April	Oct. 7	14.85	49.66	23.600
Gorobei	Iwate-ken	Avr. 25 April	Sept. 30	15.10	48.82	20.880
Iwatekameno-o	Iwate-ken	Avr. 26 April	Oct. 14	15.30	48.17	23.575
Tōgo No. 21	Fukushima-ken	Avr. 21 April	Oct. 4	15.45	47.63	21.313
Omachi	Ōsaka-fu	Mai 10 May	Oct. 22	15.55	47.29	23.875
Kameno-o	Yamagata-ken	Avr. 20 April	Sept. 26	15.90	46.10	22.373
Takasago	Yamanashi-ken	Mai 10 May	Oct. 30	16.00	45.76	22.428
Kameno-o	Manchuria	Mai 2 May	Oct. 12	16.05	45.59	22.965

Table IV. — The Activity of Catalase of the Rices which were harvested 1923 *(continued)*.

Variétés de riz The varieties of rice	Lieu de production The place of production	Date de l'ensemencement The time of sowing	Date de la récolte The time of harvest	Sol. $\frac{N}{10}$ de $KMnO^4$ cc. $\frac{N}{10}$ $KMnO_4$ titrated cc.	Décomposition de H^2O^2 en % Decomposed % of H_2O_2	Poids de 1,000 grains de riz Weight of 1,000 rice-grains
Kagawashinriki	Kagawa-ken	Avr. 25 April	Nov. 5	16.05	45.59	24.715
Omachi	Kagoshima-ken	Mai 15 May	Oct. 15	16.10	45.42	25.275
Hayashinriki	Chösen	Mai 1 May	Oct. 20	16.55	43.90	20.206
Ō-ba	Ishikawa-ken	Avr. 18 April	Sept. 13	16.80	43.05	25.218
Ishiziro	Nügata-ken	Avr. 23 April	Oct. 8	16.85	42.88	23.273
Sekitori	Gumma-ken	Mai 10 May	Nov. 3	17.00	42.37	19.348
Kokuryoto	Shimane-ken	Mai 5 May	Oct. 13	17.30	41.36	22.123
Sekitori	Saitama-ken	Mai 13 May	Nov. 1	17.45	40.85	17.819
Senichi	Tochigi-ken	Mai 27 May	Oct. 10	17.50	40.68	18.724
Seki-tori	Kanagawa-ken	Mai 7 May	Oct. 27	18.00	38.98	19.253
Kinai No. 22	Fukushima-ken	Avr. 21 April	Oct. 18	18.00	38.98	21.054
Shizuoka-Aikoku	Shizuoka-ken	Mai 1 May	Oct. 5	18.05	38.81	23.633
O-machi	Ōita-ken	Mai 2 May	Nov. 2	18.20	38.31	26.885
Toyokuni	Yamagata-ken	Avr. 20 April	Sept. 26	18.25	38.14	23.996
Bantoshinriki	Fukuoka-ken	Mai 3 May	Nov. 11	18.70	36.61	24.396
Shimehari	Chiba-ken	Avr. 29 April	Oct. 29	18 75	36.44	20.938
Omachi	Kagawa-ken	Avr. 25 April	Oct. 5	18.80	36.27	24.575
Ōba	Fukui-ken	Avr. 18 April	Sept. 15	19.00	35.59	23.800
Otoerami	Kōchi-ken	Mai 15 May	Oct. 15	19.00	35.59	23.809
Sekitori	Chiba-ken	Avr. 29 April	Oct. 17	19.35	34.41	18.583
Kagawashinriki	Kagawa-ken	Avr. 12 April	Nov. 5	19.50	33.90	24.425
Kairyoshinriki	Fukuoka-ken	Mai 15 May	Nov. 8	20.00	32.20	22.913
Aikoku	Fukushima-ken	Avr. 21 April	Oct. 18	20.25	31.36	24.305
Haziguro	Okinawa-ken	Nov. 20	Juil. 10 July	24.90	15.59	19.990
Teikyakukara	Formosa	Jan. 29	Juillet 4 July	26.95	8 64	17.496

Table V. — The Activity of Catalase of the Rices which were harvested 1922.

Variétés de riz The varieties of rice	Lieu de production The place of production	Date de l'ensemencement The time of sowing	Date de la récolte The time of harvest	Sol. $\frac{N}{10}$ de $KMnO^4$ cc. $\frac{N}{10}$ $KMnO_4$ titrated cc.	Décomposition de H^2O^2 en % Decomposed % of H_2O_2	Poids de 1.000 grains de riz Weight of 1,000 rice grains
Mubōaikoku	Saitama-ken	Mai 12 May	Oct. 11	12.05	59.15	21.308
Bōzu-gogō	Hokkaido	Mai 14 May	Sept. 27	12.15	58.81	23.134
Dōgochūtō	Ehime-ken	Mai 20 May	Oct. 20	14.30	51.87	24.746
Aikoku	Chiba-ken	Avr. 25 April	Sept. 25	14.60	50.51	22.213
Dōgo-Bantō	Ehime-ken	Mai 20 May	Oct. 27	16.25	44.92	25.754
Aikoku	Ōsaka-fu	Mai 10 May	Oct. 4	17.70	40.00	21.311
Hayashinriki	Chōsen	Mai 1 May	Oct. 15	18.10	38.64	18.538
Chusei-to	Hiroshima-ken	Avr. 30 April	Nov. 5	19.65	33.39	23.391
Omachi	Ōsaka-fu	Mai 10 May	Oct. 22	19.80	32.88	25.053
Shinriki	Mie-ken	Mai 8 May	Nov. 15	20.00	32.20	24.708
Otoerami	Kōchi-ken	Mai 15 May	Oct. 15	20.05	32.03	22.413
Ishiziro	Nügata-ken	Avr. 24 April	Oct. 7	20.80	29.49	22.047
Kairyo-Aikoku	Yamanashi-ken	Juin 10 June	Oct. 28	21.25	27.97	23.175
Tōgō	Fukushima-ken	Avr. 24 April	Oct. 20	21.80	26.10	21.605
Sekitori	Kanagawa-ken	Mai 7 May	Oct. 24	22.05	25.25	18.988
Sekitori	Saitama-ken	Mai 13 May	Oct. 25	22.85	22.54	17.152
Toyokuni	Akita-ken	Avr. 20 April	Sept. 18	22.90	22.37	22.373
Ō-mi	Saitama-ken	Mai 13 May	Nov 1	23.15	21.53	18.916
Sekitori	Chiba-ken	Avr. 25 April	Oct. 15	23.25	21.19	17.613
Shimehari	Chiba-ken	Avr. 25 April	Oct. 27	23.30	21.02	19.620
Aikoku	Ibaraki-ken	Avr. 25 April	Sept. 28	23.45	20.51	22.978
Akage	Hokkaido	Mai 11 May	Oct. 5	23.45	20.51	20.991
Sekitori	Gumma-ken	Mai 10 May	Nov. 10	24.00	18.98	18.608
Dōgo-wase	Ehime-ken	Mai 20 May	Oct. 7	24.40	17.29	22.988
Shinriki	Okayama-ken	Mai 10 May	Nov. 10	24.45	17.12	22.887
Kairyo-Shinriki	Fukushima-ken	Avr. 24 April	Oct. 20	24.95	15.42	
Kameno-o	Akita-ken	Avr. 20 April	Sept. 18	25.00	15.25	21.855
Hajiguro	Okinawa-ken	Nov. 20	Juil. 10 July	25.35	14.07	21.308
Aikoku	Miyagi-ken	Avr. 25 April	Oct. 4	25.35	14.07	23.501

Table V. — The Activity of Catalase of the Rices which were harvested 1922. *(continued).*

Variétés de riz The varieties of rice	Lieu de production The place of production	Date de l'ensemencement The time of sowing	Date de la récolte The time of harvest	Sol. $\frac{N}{10}$ de $KMnO^4$ cc. $\frac{N}{10}$ $KMnO_4$ titrated cc.	Décomposition de H^2O^2 en % Decomposed % of H_2O_2	Poids de 1.000 grains de riz Weight of 1,000 rice grains
Asahi	Kyoto-fu	Mai 4 May	Oct. 27	26.25	11.02	23.148
Ō-ba	Ishikawa-ken	Avr. 19 April	Sept. 10	27.20	7.80	22.428
Shinriki	Kumamoto-ken	Mai 14 May	Oct. 23	27.55	6.61	22.255
Shiga-Shinriki	Shiga-ken	Mai 2 May	Nov. 5	27.75	5.32	23.326
Teikyaku-Kara	Formosa	Jan. 26	Juil. 10 July	27.95	5.25	17.629
Tokushima-shinriki	Tokushima-ken	Mai 6 May	Oct. 20	28.45	3.56	23.958
Shinriki	Aichi-ken	Mai 3 May	Nov. 9	28.55	3.22	25.621

Table VI. — The Activity of Catalase of the Rices which were harvested 1921.

Variétés de riz The varieties of rice	Lieu de production The place of production	Date de l'ensemencement The time of sowing	Date de la récolte The time of harvest	Sol. $\frac{N}{10}$ de $KMnO^4$ cc. $\frac{N}{10}$ $KMnO_4$ titrated cc.	Décomposition de H^2O^2 en % Decomposed % of H_2O_2	Poids de 1.000 grains de riz Weight of 1,000 rice grains
Hayashinriki	Chōsen	Mai 1 May	Oct 16	24.05	18.48	19.010
Akage	Hokkaido	Mai 9 May	Sept. 29	24.50	16.95	20.807
Sekitori	Gumma-ken	Mai 10 May	Nov. 14	25.05	15.09	19.201
Chusei-to	Hiroshima-ken	Apr. 30 April	Nov. 5	25.20	14.58	25.218
Shinriki	Okayama-ken	Avr 25 April	Oct. 25	25.70	12.88	24.281
Shiratama	Nûgata-ken	Avr. 20 April	Oct. 5	26.00	11.86	22.258
Fukuoka-bantŏ	Fukuoka-ken	Mai 14 May	Nov. 3	26.15	11.36	20.728
Otoerami	Kochi-ken	Mai 15 May	Oct. 15	27.10	8.14	20.381
Sekitori	Kanagawa-ken	Mai 5 May	Oct. 26	27.10	8.14	17.773
Asahi	Kyoto-fu	Mai 4 May	Nov. 12	27.20	7.80	22.310
Shinriki	Mie-ken	Mai 9 May	Nov. 10	27.30	7.46	20.347
Ō-mi	Saitama-ken	Mai 13 May	Nov. 1	27.45	6.94	19.053
Shinriki No. 3	Aichi-ken	Mai 3 May	Nov. 7	27.45	6.94	21.111
Kameji	Shimane-ken	Avr. 21 April	Oct. 21	27.45	6.94	22.893
Kameno-o	Akita-ken	Avr. 25 April	Oct. 1	27.55	6.61	22.957
Hajiguro	Okinawa-ken	Nov. 25	July 15	27.60	6.44	20.860
Sekitori	Saitama-ken	Mai 13 May	Oct. 25	28.20	4.41	18.285
Teikyaku-kara	Formosa	Jan. 29	July 13	28.45	3.73	17.848

Table VII. — The Activity of Catalase of the Rices which were harvested 1920 and 1919.

Variétés de riz The varieties of rice	Lieu de production The place of production	Date de l'ensemencement The time of sowing	Date de la récolte The time of harvest	Sol. $\frac{N}{10}$ de $KMnO_4$ cc. $\frac{N}{10}$ $KMnO_4$ titrated cc.	Décomposition de H_2O_2 en % Decomposed % of H_2O_2	Poids de 1.000 grains de riz Weight of 1,000 rice grains
Shinriki	Kumamoto-ken	1910 Mai 11 May	Oct. 28	24.35	17.46	23.251
Chusei-Shinriki	Kyoto-fu	Mai 3 May	Oct. 28	24.50	16.95	25.179
Akage	Hokkaido	Mai 10 May	Sept. 27	25.95	12.03	22.005
Kikushi	Formosa	Juin 14 June	Nov. 5	26.30	10.85	15.833
Hayashinriki	Chosen	Mai 1 May	Oct. 17	26.40	10.51	20.128
Hayashinriki	Chosen	1909 Mai 1 May	Oct. 24	26.40	10.51	20.278

Explanation of Tables IV-VII.

(1) In measuring the activity of the catalase of the samples of rice the same number of rice-grains were used in each case.

(2) The activity differs widely in different varieties of rice.

(3) The activity also differs according to the locality in which the rice was produced.

(4) The activity differs widely according to the length of time that has elapsed between the time of harvesting the rice and the time of the experiment.

I felt that it was very important to determine the relationships between the activity of rice-catalase and the following factors:

(*a*) The varieties of rice.

(*b*) The locality of the production of the rice.

(*c*) The age of the stock of rice.

(*d*) The grade of polishing.

(a) *The Relationship between the Activity of Rice-catalase and the Varieties of Rice.*

The weight of 1,000 rice-grains differs in the different varieties of rice. The relationship between the activity of the catalase and the weight of 1,000 grains is shown in Table VIII. These results show that there is no relation between the activity and the weight of the rice-grains.

Table VIII. — The Relationship between the Activity of Catalase and the Weight of 1,000 grains.

Variétés de riz Varieties of rice	Lieu de production Place of production	Poids de 1.000 grains de riz (gr.) Weight of 1,000 rice-grains (gms.)	Décomposition de H^2O^2 en % Decomposed % of H_2O_2
Sekitori	Saitama-ken	17.819	40.85
Sekitori	Kanagawa-ken	19.253	38.98
Ō-mi	Saitama-ken	18.645	64.41
Senichi	Tochigi-ken	18.724	40.68
Kokuryo-to	Shimane-ken	22.124	41.36
Aikoku	Ōsaka-fu	22.126	52.71
Shinriki	Kumamoto-ken	22.206	50.68
Kameno-o	Yamagata-ken	22.373	46.10
Kagawashinriki	Kagawa-ken	24.356	69.32
Toyokuni	Akita-ken	24.383	50.85
Banseishinriki	Fukuoka-ken	24.396	36.61
Omachi	Kagawa-ken	24.575	36.27
Dōgochūtō	Ehime-ken	25.145	54.91
Ō-ba	Ishikawa-ken	25.218	43.05
Omachi	Kagoshima-ken	25.275	45.42
Shinshinriki	Hyogo-ken	26.130	57.80

The comparison of samples of the same variety of rice differing only in the locality of production is shown in Table IX. The activity of rices of the same variety is similar if the samples are taken from neighbouring localities, but the activity of samples of the same variety differs if they are taken from localities which are far a part.

Table IX. — The Comparison of the Activity of the Rice-Catalase of the same Variety.

Variétés de riz Varieties of rice	Lieu de production Place of production	Sol $\frac{N}{10}$ de $KMnO^4$, cc. $\frac{N}{10}$ $KMnO_4$ titrated cc.	Décomposition de H^2O^2 en % Decomposed % of H_2O_2	Poids de 1000 grains de riz Weight of 1,000 rice-grains
Aikoku	Chiba-ken . . .	6.90	76.61	24.085
»	Ōsaka-fu	13.95	52.71	22.126
Shizuoka-aikoku	Shizuoka-ken . .	18.05	38 81	23,633
Aikoku No. 20 .	Fukushima-ken .	20.25	31.36	24.305
Aikoku	Miyagi-ken . . .	20.65	30.00	23.753
Shinriki	Okayama-ken . .	8.85	70.00	22.638
Kagawa-shinriki	Kagawa-ken. . .	9.05	69.32	24.356
Shin-shinriki . .	Hyogo-ken . . .	12.45	57.80	26.130
Bansei-shinriki .	Hukuoka-ken . .	13 30	54.91	22.693
» » .	Wakayama-ken .	13.80	53.22	24.775
Shinriki	Kumamoto-ken .	14.55	50.68	22.206
Haya-shinriki. .	Chōsen	16.55	43.90	20.206
Tokushima-shinriki	Tokushima-ken .	10.30	65.09	23.285
Sekitori	Gumma-ken . .	17.00	42.37	19.348
»	Saitama-ken. . .	17.45	40.85	17.819
»	Kanagawa-ken .	18.00	38.98	19.253
»	Chiba-ken . . .	19.35	34.41	18.583
Omachi	Ōsaka-fu	15.55	47.29	23.875
»	Kagoshima-ken .	16.10	45.42	25.275
»	Ōita-ken	18.20	38.31	26.885
»	Kagawa-ken. . .	18.80	36.27	24.575
Kameno-o . . .	Akita-ken . . .	14.85	49.66	23.600
Iwate-kameno-o	Iwate-ken . . .	15.30	48.17	23 575
Kameno-o . . .	Yamagata-ken .	15.90	46.10	22.373
Yamagata-kameno-o	Yamagata-ken. .	16.50	44.07	22.614

(b) *The Relationship between the Activity of Rice-catalase and the Locality of Production of the Rice.*

Japan is usually divided as follows: Inland, Okinawa, Formosa, Korea (Chosen), Hokkaido and Saghalien. Inland is divided into nine divisions as follows:

Tōhoku	(6 provinces)	Kinki	(6 provinces)
Kwanto	(7 »)	Chūgoku	(5 »)
Hokuriku	(4 »)	Shikoku	(4 »)
Tōsan	(3 »)	Kyushu	(7 »)
Tōkai	(3 »)		

Table X shows the comparison of the activities of rice-catalase from samples obtained from these divisions.

There is no relation between the activity and the locality of the production of the rice. But the activity of Hokkaido rice is the strongest, while that of Formosa rice is the weakest.

Table X. — The Comparison of the Activity of the Rice-Catalase of the Same Locality.

Variétés de riz Varieties of rice	Lieu de production The place of production	Sol $\frac{N}{10}$ de $KMnO_4$, cc. $\frac{N}{10}$ $KMnO_4$ titrated cc.	Décomposition de H^2O^2 en % Decomposed % of H_2O_2	Poids de 1.000 grains de riz Weight of 1,000 rice-grains
Division de Tōhoku. — Tōhoku Division.				
Toyokuni . . .	Akita-ken . . .	14.50	50.85	24.383
Kameno-o . . .	Akita-ken . . .	14.85	49.66	23.600
Gorobei	Iwate-ken . . .	15.10	48.82	20.880
Iwate-kameno-o	Iwate-ken . . .	15.30	48.17	23.575
Togo No. 21 . .	Fukushima-ken .	15.45	47.63	21.313
Kinai No. 22 .	Fukushima-ken .	18.00	38.98	21.054
Toyokuni . . .	Yamagata-ken .	18.25	38.14	23.996
Aikoku	Miyagi-ken . . .	20.65	30.00	23.753
I-gō	Yamagata-ken .	16.50	44.07	22.614
Nioi-wase . . .	Miyagi-ken . . .	16.50	44.07	20.893
Toyokuni No. 2.	Yamagata-ken .	16.50	44.07	23.689
Division de Hokuriku. — Hokuriku Division.				
Ishiziro . . .	Nii Gata-ken . .	16.85	42.88	23.273
Ō-ba	Fukui-ken . . .	19.00	35.59	23.800
»	Ishikawa-ken . .	16.80	43.05	25.218
»	Toyama-ken. . .	13.50	54.24	17.786
Watarō	Toyama-ken. . .	14.30	51.53	23.625
Ishiziro	Toyama-ken. . .	19.50	33.90	23.329
Division de Tokai. — Tokai Division.				
Shizuoka-Aikoku	Shizuoka-ken . .	18.05	38.81	23.633
Shinriki No. 3	Aichi-ken	21.80	26.10	23.508

Table X. — The Comparison of the Activity of the Rice-Catalase of the Same Locality *(coutinued)*

Division de Kwanto. — Kwanto Division.				
Aikoku	Chiba-ken . . .	6.90	76.61	24.085
Yasumura . . .	Saitama-ken. . .	8.00	72.88	22.570
Ō-mi	Saitama-ken. . .	10.05	64.41	18.645
Sekitori	Gumma-ken . .	17.00	42.37	19.348
Sekitori	Saitama-ken. . .	17.45	40.85	17.819
Sen-ichi	Tochigi-ken . . .	17.50	40.68	18.724
Sekitori	Kanagawa-ken .	18.00	38.98	19.253
Shimehari . . .	Chiba-ken . . .	18.75	36.44	20.938
Sekitori	Chiba-ken . . .	19.35	34.41	18.583
Division de Kinki — Kinki Division.				
Shinshinriki . .	Hyogo-ken . . .	12.45	57.80	26.130
Aikoku No. 1. .	Ōsaka-fu	13.95	52.71	22.126
Omachi	Ōsaka-fu	15.55	47.29	23.875
Omachi	Nara-ken	7 45	74.75	25.378
Aikoku No. 2. .	Ōsaka-fu	11.30	61.70	23.773
Division de Chūgoku. — Chūgoku Division.				
Chusei-to No. 1	Hiroshima-ken. .	14.70	50.17	23.898
Shinriki	Okayama-ken . .	8.85	70.00	22.638
Chusei-to No. 2	Hiroshima-ken. .	15.95	45.93	24.456
Division de Shikoku. — Shikoku Division.				
Kagawa-shinriki No. 1	Kagawa-ken. . .	9.05	69.32	24.356
Dōgo-chūtō . .	Ehime-ken . . .	13.30	54.91	25.145
Shinriki	Kagawa-ken. . .	19.50	33.90	24.425
Kagawa-shinriki No. 2	Kagawa-ken. . .	16.05	45.59	24.715
Tokushimashin-riki	Tokushima-ken .	10.30	65.09	24.946
Otoerami . . .	Kōchi-ken . . .	18.20	38.31	23.142

Table X. — The Comparison of the Activity of the Rice-Catalase of the Same Locality *(continued)*.

Division de Kyushu. — Kyushu Division.				
Omachi	Kagoshima-ken .	16.10	45.42	25.275
Kairyo-shinriki .	Fukuoka-ken . .	20.00	32.20	22.913
Bansei-shinriki .	Kumamoto-ken .	13.30	54.91	22.693
Shinriki	Kumamoto-ken .	14.55	50.68	22.206
Omachi	Ōita-ken	18.20	38.31	26.885
Banto-shinriki .	Fukuoka-ken .	18.70	36.61	24.396
Benkei	Ōita-ken	12.25	58.48	27.359
Hajiguro . . .	Okinawa-ken . .	15.00	49.15	19.732
Division de Hokkaido. — Hokkaido Division.				
Akage	Hokkaido . . .	7.20	75.59	20.937
Bōzu No. 5. . .	Hokkaido . . .	8.05	72.71	23.220
Mandchourie. — Manchuria.				
Kōkōtōji . . .	Manchuria . . .	6.55	77.80	23.302
Kameno-o . . .	Manchuria . . .	16.05	45.59	22.965
Kameno-o . . .	Manchuria . . .	11.50	61.02	23.003
Formose. — Formosa.				
Teikyaku-kara No. 1	Taihoku	26.95	8.64	17.496
Teikyaku-Kara No. 2	Taihoku	23.50	20.34	23.508
Chōsen. — Chōsen.				
Hayashinriki No.1	Suigen	16.55	43.90	20.206
Hayashinriki No.2	Suigen	19.40	34.24	20.232

(c) *The Relationship between the Activity of Rice-catalase and the Age of the Stock of Rice.*

In order to follow the changes in the activity of rice-catalase, I determined the activity twice, the first time in the December of the year in which the rice was harvested, and the second time in December of the next year. The rice was stored carefully in a natural state during the year. The results are shown in Table XI.

Table XI. — The Change of the Activity of Rice-Catalase during One Year.

Variétés de riz Varieties of rice	Lieu de production Place of production	Riz nouveau New rice		Riz conservé pendant une année Rice preserved one year	
		Sol. $\frac{N}{10}$ de $KMnO_4$, cc. $\frac{N}{10}$ $KMnO_4$ titrated, cc.	Décomposition de H_2O_2 en % Decomposed % of H_2O_2	Sol. $\frac{N}{10}$ de $KMnO_4$, cc. $\frac{N}{10}$ $KMnO_4$ titrated, cc.	Décomposition de H_2O_2 en % Decomposed % of H_2O_2
Aikoku	Aichi-ken . . .	10.05	64.41	21.35	27.53
Chūsei-to . .	Hiroshima-ken .	14.70	50.17	22.60	23.39
Toyokuni . . .	Akita-ken . . .	14.50	50.85	22.90	22.37
Toyokuni . . .	Yamagata-ken .	16.50	44.07	23.35	20.85
Kameno-o. . .	Akita-ken . . .	14.85	49.66	22.05	25.25
Kameno-o. . .	Manchuria . . .	16.05	45.59	22.95	22.20
Omachi . . .	Kagoshima-ken	15.55	47.29	22.75	22.88
Omachi . . .	Nara-ken . . .	15.55	47.29	21.05	28.64
Shinriki . . .	Fukuoka-ken .	16.00	45.76	21.25	27.97
Shinriki . . .	Kumamoto-ken	13.30	54.91	21.80	26.10
Shinriki . . .	Mie-ken	13.80	53.22	23.30	21.02
Sekitori . . .	Kanagawa-ken .	17.65	40.65	22.85	22.54
Sekitori . . .	Gumma-ken . .	17.00	42.37	24.00	18.98
Sekitori . . .	Saitama-ken . .	17.45	40.85	23.45	20.51
Sen-ichi . . .	Tochigi-ken . .	17.50	40.68	22.55	23.73
To-go.	Fukushima-ken .	15.45	47.63	21.80	26.10
Fuji	Shiznoka-ken .	14.70	50.17	23.40	20.68
Dōgo-chūtō .	Ehime-ken . . .	13.30	54.91	23.00	22.03
Bōzu No. 5 . .	Hokkaido . .	8.05	72.71	19.35	34.41
Hayashinriki .	Chōsen	16.55	43.89	24.05	18.48

The change of activity measured bi-monthly is shown in Table XII. Figure I gives the results of Table XII.

The activity diminishes gradually during storage. The diminution of activity occurs most rapidly after May of the year following the harvesting. The amount of hydrogen peroxide decomposed is reduced to about one-half in a year. The course of the diminution of activity in the following year is the same.

Table XII. — The Change of the Activity of Rice-catalase which was measured bi-monthly

Varietés de riz Varieties of Rice	Aikoku		Kameno-o		Omachi		Sekitori		Shinriki	
Mois Month	$N/10$ $KMnO_4$ cc.	Décomposé Decomposed %	$N/10$ $KMnO_4$ cc.	Décomposé Decomposed %	$N/10$ $KMnO_4$ cc.	Décomposé Decomposed %	$N/10$ $KMnO_4$ cc.	Décomposé Decomposed %	$N/10$ $KMnO_4$ cc.	Décomposé Decomposed %
November . .	10.05	64.41	14.85	49.66	15.55	47.29	17.50	40.68	13.30	54.91
January. . .	11.00	62.54	15.10	48.81	15.55	47.29	17.70	40.00	13.40	54.57
March . . .	12.05	59.15	15.30	48.17	15.90	46.10	18.00	38.98	13.60	53.89
May	13.30	54.91	15.90	46.10	17.00	42.37	18.25	38.14	14.30	51.87
July	17.30	41.36	17.60	40.45	19.65	33.39	19.35	34.40	16.55	43.90
September. .	20.65	30.00	20.00	32.20	22.05	25.25	22.20	24.74	19.80	32.88
November . .	21.35	27.53	22.05	25.25	22.75	22.88	22.85	22.54	21.80	26.10
January. . .	21.80	26.10	22.70	23.05	23.25	21.19	22.85	22.54	22.05	25.25
March . . .	22.70	23.05	23.45	20.51	24.00	18.98	23.00	22.03	22.05	25.25
May	23.60	20.00	24.90	15.59	25.70	12.88	23.00	22.03	24.00	18.98
July	25.95	12.03	27.45	6.61	26.40	10.51	26.15	11.36	25.20	14.58
September. .	27.10	8.14	27.45	6.61	26.90	8.81	26.40	10.51	26.40	10.51
November . .	27.25	7.63	27.45	6.61	26.90	8.81	27.10	8.14	27.30	7.46

(d) *The Relationship between the Activity of Rice-catalase and the Grade of Polishing.*

I used three varieties of rice, each of which was divided into the four following parts, according to the grade of polishing:

(*a*) Unpolished rice.
(*b*) 50%-polished rice.
(*c*) 70%-polished rice.
(*d*) Polished rice (white rice).

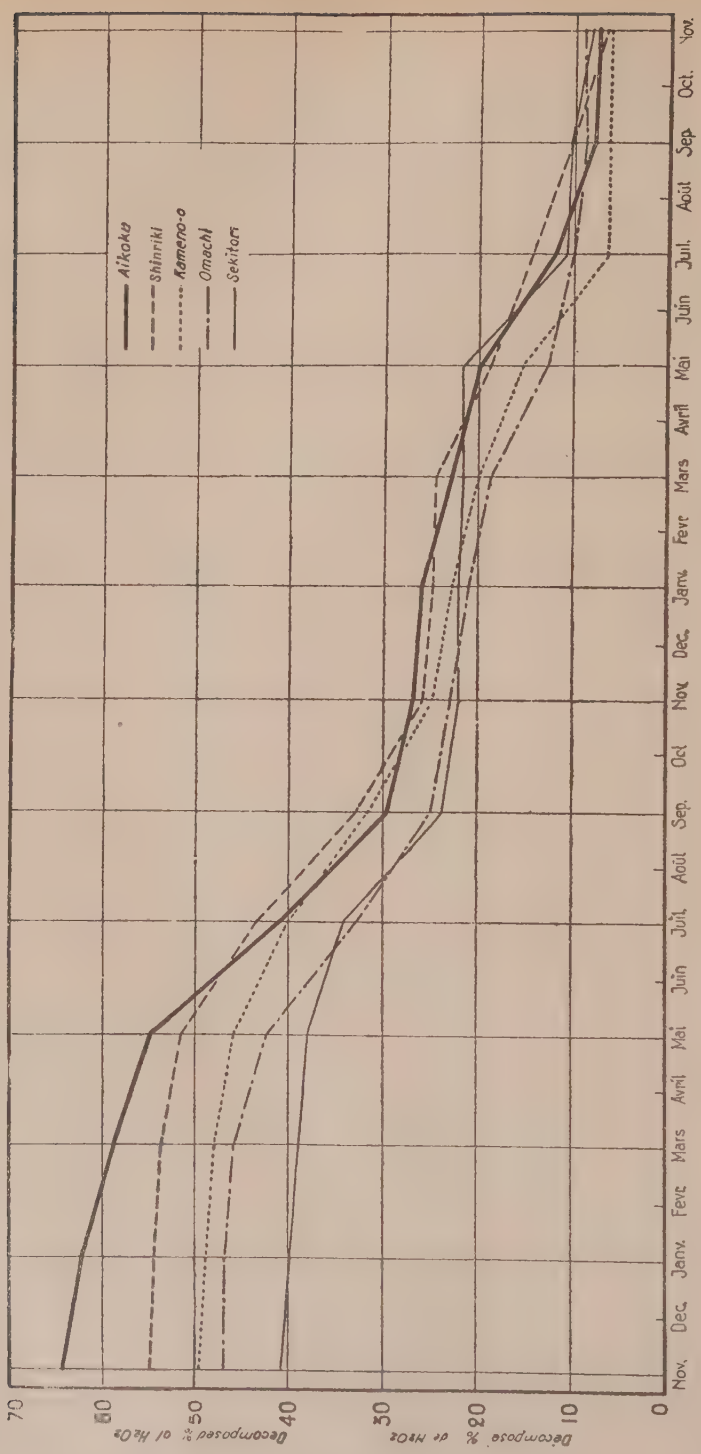


Fig. I. — The Change of the Activity of Rice-catalase during two Years.

I determined the activity of each sample; the results are shown in Table XIII and Figure II.

The activity diminishes according to the grade of polishing; the activity of polished rice is about one-fifth or one-sixth of that of unpolished rice.

The comparison of the activities of unpolished and polished rice is shown in Table XIV.

Table XIII. — The Activity of the Catalase of the Rices which differ from the Grade of Polishing.

	Shonai rice			Niigata rice			Miyagi rice		
	$\frac{N}{10}$ $KMnO_4$ Titré - Titrated	Décomposé % de H^2O^2 Decomposed % of H_2O_2	Poids de 1000 grains Weight of 1000 grains	$\frac{N}{10}$ $KMnO_4$ Titré - Titrated	Décomposé % de H_2O_2 Decomposed % of H_2O_2	Poids de 1000 grains Weight of 1000 grains	$\frac{N}{10}$ $KMnO_4$ Titré - Titrated	Décomposé % de H^2O^2 Decomposed % of H_2O_2	Poids de 1000 grains Weight of 1000 grains
Riz non glacé . Unpolished rice	16.80	43.05	22.616	15.85	46.27	22.975	14.50	50.85	21.767
Riz glacé à 50% . 50% polished rice	24.35	17.46	21.804	23.65	19.83	22.043	23.00	22.03	21.240
Riz glacé à 70% 70% polished rice	26.25	11.02	21.583	26.00	11.86	21.595	26.15	11.36	20.690
Riz glacé . . . Polished rice .	27.50	6.78	20.628	27.35	7.29	21.109	26.85	8.98	20.340

The Figure of the Results of Table XIII.

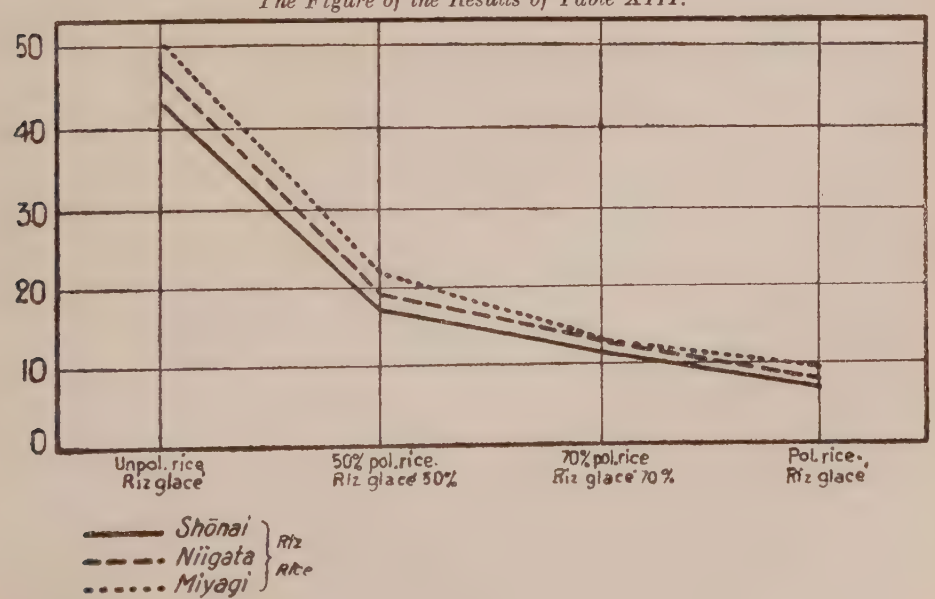


Table XIV. — Comparison of the Activity of the Catalase of Unpolished and its Polished Rice.

Variétés de riz Varieties of rice	Lieu de production The place of production	Année de récolte The year harvested	Riz non glacé Unpolished rice			Riz glacé Polished rice		
			Sol $\frac{N}{10}$ de $KMnO^4$ cc. $\frac{N}{10}$ $KMnO_4$ titrated cc.	Décomposition de H^2O^2 en% Decomposed % of H_2O_2	Poids de 1.000 grains de riz Weight of 1,000 grains	Sol $\frac{N}{10}$ de $KMnO^4$ cc. $\frac{N}{10}$ $KMnO^4$ titrated cc.	Décomposition de H^2O^2 en % Decomposed % of H_2O_2	Poids de 1.000 grains de riz Weight of 1,000 grains
Gorobei	Iwate-ken	1924	15.10	48.82	20.880	27.55	6.61	19.123
Toyokuni	Akita-ken	1923	22.90	22.37	22.373	28.20	4.41	20.273
Toyokuni	Akita-ken	1924	14 50	50.85	24.383	27.30	7.46	20.275
Ishiziro	Niigata-ken	1923	20.80	29.49	22.047	28.50	3.39	20.445
Ishiziro	Niigata-ken	1924	16.85	42.88	23.273	28.45	3.56	17.983
Dŏgowase	Ehime-ken	1923	24.40	17.29	22.988	28.40	3.73	22.118
Dŏgowase	Ehime-ken	1924	21.40	27.46	22.800	27.60	6.44	21.995
Dŏgochŭtŏ	Ehime-ken	1923	14.30	51.87	27.746	28.35	3.89	22.153
Dŏgochŭtŏ	Ehime-ken	1924	13.30	54.91	25.145	25.85	5.59	22.985
Dŏgobantŏ	Ehime-ken	1923	16.25	44.92	25.754	28.30	4.07	21.995
Dŏgobantŏ	Ehime-ken	1924	23.00	22.03	24.458	27.70	6.10	22.703
Hajiguro	Okinawa-ken	1922	27.60	6.44	20.860	28.75	2.54	19.788
Hajiguro	Okinawa-ken	1923	25.35	14.07	21.308	28.40	3.73	19.658
Hajiguro	Okinawa-ken	1924	24.90	15.59	19 990	27.80	5.76	19.594

Table XV. — The Activity of the Catalase of Polished Rice.

Variétés de riz Varieties of Rice	Lieu de production Place of production	Sol. $\frac{N}{10}$ de $KMnO_4$, c.c. $\frac{N}{10}$ $KMnO_4$ titrated c.c.	Décomposition de H^2O^2 en % Decomposed % of H_2O_2
Sekitori	Kanagawa-ken	26.85	8.98
Sen-ichi	Tochigi-ken	28.30	4.07
Ō-mi	Saitama-ken	28.20	4.41
Mubō-aikoku	Saitama-ken	27.10	8.14
Sekitori	Gumma-ken	27.75	5.32
Shiratama	Kanagawa-ken	28.45	3.56
Shimehari	Chiba-ken	27.10	8.14
Aikoku	Chiba-ken	27.35	7.29
Meijinishiki	Yamanashi-ken	28.35	3.89
Takasago	Yamanashi-ken	28.40	3.73
Togokuni	Yamagata-ken	27.30	7.46
Togō	Fukushima-ken	28.40	3.73
Kameno-o	Akita-ken	27.45	6.94
Kameno-o	Yamagata-ken	27.20	7.79
Iwate-kameno-o	Iwate-ken	27.30	7.46
Ō-ba	Toyama-ken	27.60	6.44
Ishijiro	Nügata-ken	27.35	7.29
Ishijiro	Toyama-ken	26.00	11.86
Watarō	Toyama-ken	27.30	7.46
Ginbōzu	Toyama-ken	27.20	7.78
Shinriki	Mie-ken	28.35	3.73
Shinriki	Aichi-ken	28.50	3.39
Shiga-shinriki	Shiga-ken	28.20	4.41
Omachi	Ōsaka-fu	27.45	6.94
Shinshinriki	Wakayama-ken	28.10	4.75
Oto-erami	Kōchi-ken	28.20	4.41
Chūsei-to	Hiroshima-ken	26.25	11.02
Kokuryo-to	Shimane-ken	27.95	5.25
Omachi	Kagoshima-ken	27.55	6.61
Shinriki	Fukuoka-ken	27.60	6.44
Omachi	Ōita-ken	28.45	3.56
Teikyakukara	Formosa	27.30	7.46
Hayashinriki	Chōsen	27.25	7.63
Bōzu No. 5	Hokkaido	26.85	8.98
Akage	Hokkaido	27.10	8.14

The activities of polished rices collected from all over Japan are shown in Table XV. It is seen that the activity of polished rice is always weak and very variable.

Dr. Fujimaki and Matsumuro have found that the quantity of vitamin B is diminished by the storage of rice and by the different grades of polishing. We found that the decrease of vitamin B ran approximately parallel to the decrease of catalase activity. It might therefore be possible to estimate the quantity of vitamin B in rice by means of the catalase reaction.

Conclusions.

(1) The activity of the catalase of rice differs widely in different varieties of rice and varies according to the locality in which the rice is produced.

(2) The activity of samples of the same variety of rice is similar if they are taken from neighbouring localities; but the activity of samples of rices of the same variety differ if they are taken from localities which are far apart.

(3) The activity of Hokkaido rice is the strongest, while that of Formosa rice is the weakest.

(4) Even when the same variety is produced in the same locality, the activity varies according to the length of time the rice has been stored.

(5) There is no relation between the activity and the weight of the rice grains.

(6) The activity of the catalase of rice varies according to the grade of polishing.

(7) The diminution in the activity of the catalase during a year's storage runs parallel with the decrease of vitamin B content of the rice.

The results of the experiments performed on rice-catalase by Noguchi, of the Ōhara Institute for Agriculture, are quite different from my own. In all the catalase reactions I used the same number of rice-grains, so that I was able to determine exactly the change in the activity of the catalase during the period of storage of the rice. All the experiments were made on rice kept in a natural state.

Experiments are still being continued on the relationship between the activity of the catalase and the state of moisture in which the rice is kept.

14.

THE RELATIONSHIP BETWEEN THE CHEMICAL COMPOSITION OF RICE AND ITS DIFFERENT GRADES OF POLISHING.

By

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Introduction.

Polished rice is the principal food of the Japanese; it is more digestible and better utilised in the body than unpolished rice, and it has a pleasanter taste. In Japan, many people used to consume about half-polished rice, but recently they have become accustomed to using finely polished rice. The food value of polished rice is less, because part of the rice grain is lost by polishing. There are good reasons for recommending the Japanese people to acquire the habit of using only partially polished rice. We have studied the deterioration of rice produced by different grades of polishing and present our results in this report.

Experimental Methods.

We used the polishing machine of the Institute for polishing the experimental rice. Each sample of rice was divided into the four following fractions according to the grade of polishing:

(a) *Unpolished rice.* — Rice from which the husk had been removed, but which still retained the outer layer, or silver skin, and the embryo or germ.

(b) 50%-*polished rice.* — Rice which had been milled and polished but which retained half of the outer layer and germ.

(c) 70%-*polished rice.* — Rice which still retained about 30 per cent of the outer layer and germ.

(d) *Polished rice (white rice).* — Rice which had been polished perfectly, so that the germ was almost entirely rubbed off in the milling.

We collected a number of samples, and a few characteristic varieties of rice were taken for analysis.

No. I. Shonai rice (rice of 3rd class A).
No. II. Miyagi rice (rice of 2nd class).
No. III. Niigata rice (rice of 1st class).
No. IV. Shonai rice (rice of 3rd class B).

Each sample of rice was powdered and an investigation was made of its chemical components. The analysis was made by the methods given in the book "Analytical Methods of Agricultural Chemistry", published by the Agricultural College of the Tokyo Imperial University (1921).

Experiment I.

Sample: Shonai rice A. The results of analysis are shown in Table I.

Table I.

	Eau Water	Protéine Protein	Graisse Fat	Cendres Ash	Cellulose Fibre	Hydrates de carb. Carbo-hydrates
Riz non glacé . . . Unpolished rice . .	15.05	7.50	2.39	1.31	1.79	71.96
Riz glacé à 50% . . . 50% polished rice . .	15.19	6.67	1.29	0.78	0.92	75.15
Riz glacé à 70% . . 70% polished rice . .	15 28	6.37	1.00	0.58	0.66	76.11
Riz glacé . . . . . Polished rice . . .	15.18	6.24	0.50	0.46	0.36	77.26

That is, protein, fat, ash and fibre are gradually diminished by the grade of polishing.

We compared the components of the rice of each grade of polishing with those of unpolished rice (100), as shown in Table II.

Table II.

	Protéine Protein	Graisse Fat	Cendres Ash	Cellulose Fibre
Riz non glacé . . . . . Unpolished rice	100.00	100.00	100.00	100.00
Riz glacé à 50% . . . . . 50% polished rice	88.93	53.97	59.54	51.40
Riz glacé à 70% . . . . . 70% polished rice	84.93	41.84	44.27	36.87
Riz glacé . . . . . Polished rice	83.20	20.92	35.11	20.11

Experiment II.

Sample: Miyagi rice. The results of analysis are shown in Table III.

Table III.

	Eau Water	Protéine Protein	Graisse Fat	Cendres Ash	Cellulose Fibre	Hydrates de carb. Carbo-hydrates
Riz non glacé . . . Unpolished rice . .	14.45	8.24	2.11	1.26	1.37	72.57
Riz glacé à 50% . . 50% polished rice . .	14.53	8.12	2 04	1.24	1.32	72.75
Riz glacé à 70% . . 70% polished rice . .	14.75	7.99	1.77	1.11	1.07	73.31
Riz glacé . . . . . Polished rice . . .	15.36	7.52	0.94	0.71	0.69	74.78

We compared the components of the rice of each grade of polishing with those of unpolished rice (100), as shown in Table IV.

Table IV.

	Protéine Protein	Graisse Fat	Cendres Ash	Cellulose Fibre
Riz non glacé . . . . . Unpolished rice	100.00	100.00	100.00	100.00
Riz glacé à 50% . . . . . 50% polished rice	98.54	96.68	98.41	96.35
Riz glacé à 70% . . . . . 70% polished rice	96.97	83.89	88.10	78.10
Riz glacé . . . . . Polished rice	91.26	44.55	56.35	50.36

Experiment III.

Sample: Niigata rice. The results are shown in Table V.

Table V.

	Eau Water	Protéine Protein	Graisse Fat	Cendres Ash	Cellulose Fibre	Hydrates de carb. Carbo-hydrates
Riz non glacé . . . Unpolished rice . .	14.75	7.40	2.34	1.25	1.29	72.97
Riz glacé à 50% . . 50% polished rice . .	14.97	7.00	1.45	0.88	0.60	75 10
Riz glacé à 70% . . 70% polished rice . .	15.16	6.66	1.30	0.75	0.48	75.65
Riz glacé . . . . . Polished rice . . .	15.33	6.56	0.78	0.53	0.45	76.35

We compared the components of the rice of each grade of polishing with those of unpolished rice (100), as shown in Table VI.

Table VI.

	Protéine Protein	Graisse Fat	Cendres Ash	Cellulose Fibre
Riz non glacé . . . . . Unpolished rice	100.00	100.00	100.00	100.00
Riz glacé à 50% . . . . . 50% polished rice	94.59	61.97	70.40	46.51
Riz glacé à 70%. . . . . 70% polished rice	90.00	55.56	60.00	37.21
Riz glacé . . . . . Polished rice	88.65	33.33	42.40	34.88

Experiment IV.

Sample: Shonai rice B. The results of analysis are shown in Table VII.

Table VII.

	Eau Water	Protéine Protein	Graisse Fat	Cendres Ash	Cellulose Fibre	Hydrates de carb. Carbo-hydrates
Riz non glacé . . . Unpolished rice . .	15.37	7.19	2.66	1.39	1.50	76.89
Riz glacé à 50% . . 50% polished rice . .	15.65	6.69	1.88	0.99	1.16	73.63
Riz glacé à 70% . . 70% polished rice . .	15.85	6.50	1.18	0.70	1.09	74.68
Riz glacé . . . . . Polished rice . . .	15.81	6.00	0.50	0.51	0.73	76.45

We compared the components of the rice of each grade of polishing with those of unpolished rice (100), as shown in Table VIII.

Table VIII.

	Protéine Protein	Graisse Fat	Cendres Ash	Cellulose Fibre
Riz non glacé . . . . . . Unpolished rice	100.00	100.00	100.00	100.00
Riz glacé à 50% . . . . . . 50% polished rice	93.05	70.68	71.22	77.33
Riz glacé à 70% . . . . . . 70% polished rice	90.40	44.36	50.36	72.67
Riz glacé . . . . . . Polished rice	83.45	18.79	36.69	48.67

Figures I to IV show the comparison of the quantity of each component of the rices of the different grades of polishing in Experiments I to IV.

Fig. I. — Comparison of the Quantity of Protein in the Rices of Different Grades of Polishing.

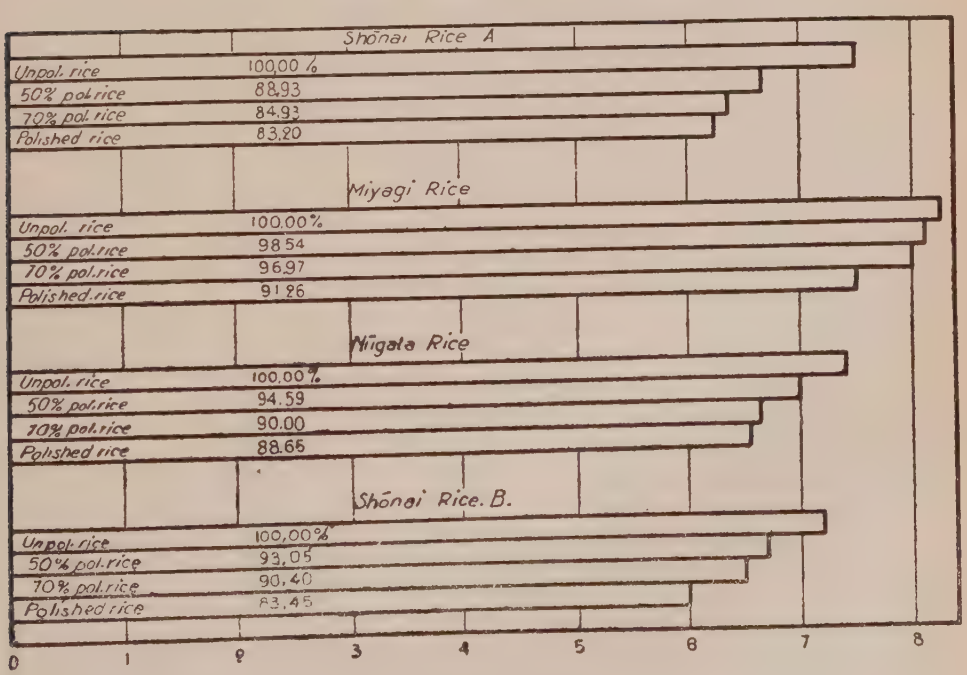


Fig. II. — Comparison of the Quantity of Fat in the Rices of Different Grades of Polishing

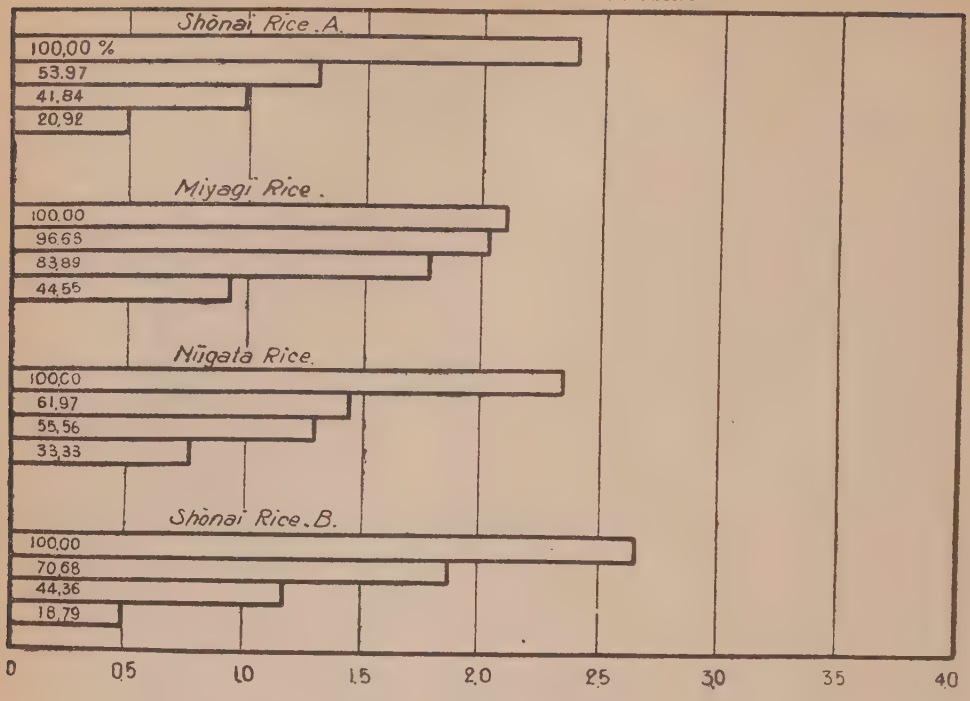


Fig. III. — Comparison of the Quantity of Ash in the Rices of Different Grades of Polishing.

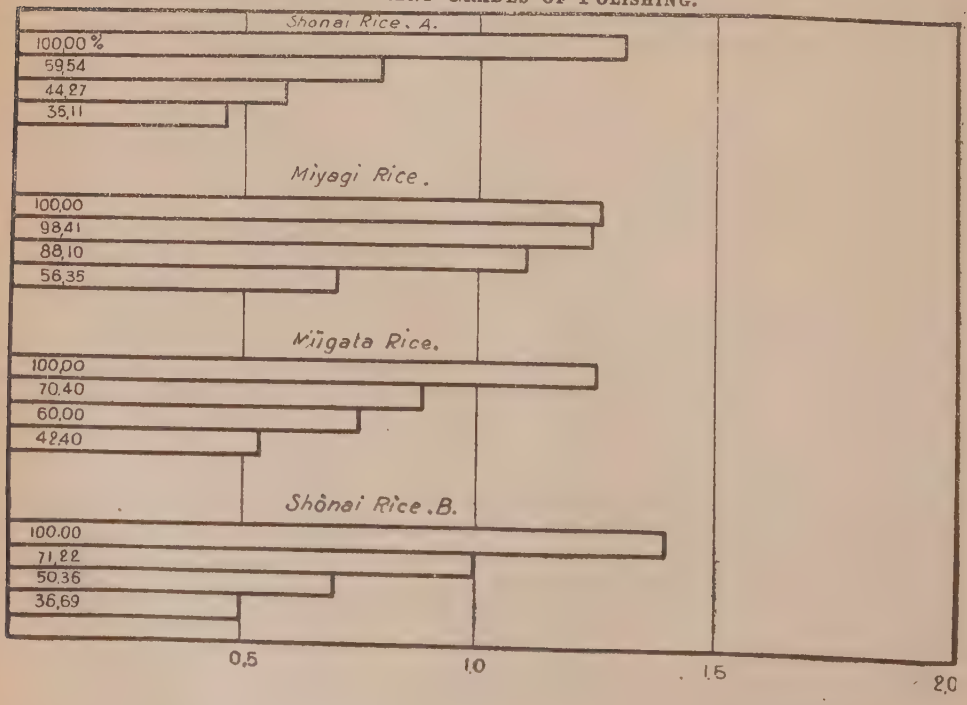


Fig. IV. — Comparison of the Quantity of Fibre in the Rices of Different Grades of Polishing.

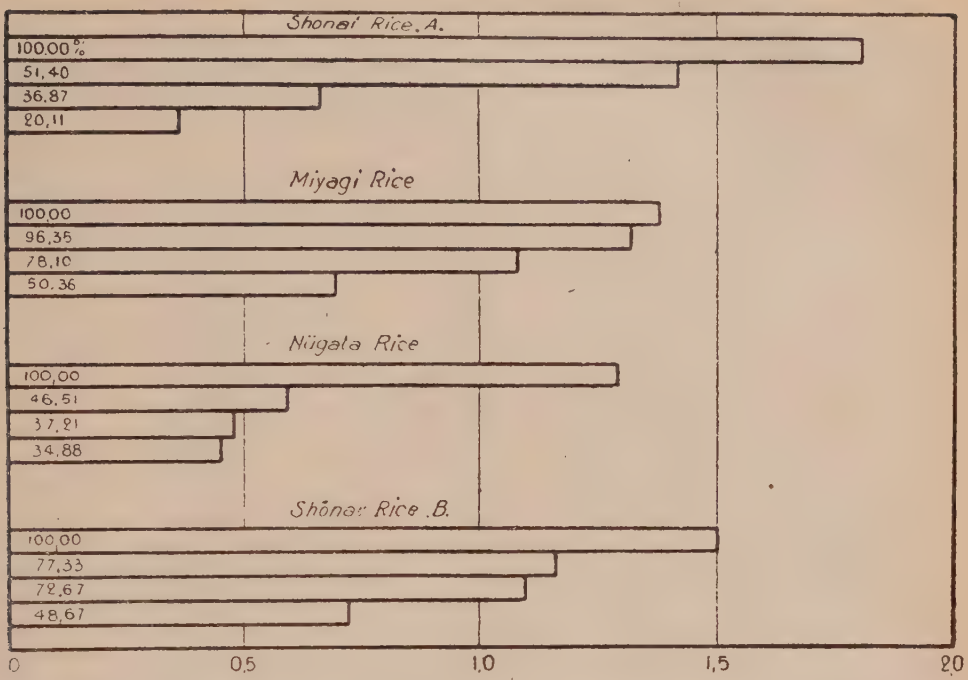


Table IX shows the loss (per cent) of each chemical component of the rices in the different grades of polishing.

Table IX.

		Protéine Protein	Graisse Fat	Cendres Ash	Cellulose Fibre
Riz A de Shōnai Shōnai rice A.	Riz non glacé Unpolished rice	0.00	0.00	0.00	0.00
	Riz glacé à 50% 50% polished rice	11.07	46.03	40.46	48.60
	Riz glacé à 70% 70% pol. rice	15.07	58.16	55.73	63.13
	Riz glacé Polished rice	16.80	79.08	64.89	79.89
Riz de Miyagi Miyagi rice	Riz non glacé Unpolished rice	0.00	0.00	0.00	0.00
	Riz glacé à 50% 50% pol. rice	1.46	3.32	1.59	3.65
	Riz glacé à 70% 70% pol. rice	3.03	16.11	11.90	21.90
	Riz glacé Polished rice	8.74	55.45	43.65	49.64

Table IX *(continued).*

		Protéine Protein	Graisse Fat	Cendres Ash	Cellulose Fibre
Riz de Niigata Niigata rice	Riz non glacé Unpolished rice	0.00	0.00	0.00	0.00
	Riz glacé à 50% 50% pol. rice	5.41	38.03	29.60	53.49
	Riz glacé à 70% 70% pol. rice	10.00	44.44	40.00	62.79
	Riz glacé Polished rice	11.35	66.67	57.60	65.12
Riz B de Shōnai Shōnai rice B	Riz non glacé Unpolished rice	0.00	0.00	0.00	0.00
	Riz glacé à 50% 50% pol. rice	6.95	29.32	28.78	22.67
	Riz glacé à 70% 70% pol. rice	9.60	55.64	49.64	27.33
	Riz glacé Polished rice	16.55	81.21	63.31	51.33

Summary of Experiments I to IV.

(1) Protein is slightly diminished by polishing.

(2) Fat, ash and fibre are greatly diminished by polishing.

(3) Carbohydrates are slightly increased and the other nutrients are diminished.

(4) The grade of polishing differs from the varieties of rice.

The germ is an important part of rice as it contains vitamin B. So we should avoid its removal by polishing; the polished rice used in the city contains no germ. It has been already proved that the rice germ also contains a great deal of phosphorus.

The most noteworthy nutrients lost by polishing are the inorganic substances; we have therefore analysed the inorganic substances of rice. The components of the inorganic substances of rice (Shonai rice B) are shown in Table X. (The figures are the percentages in ash.)

Table X.

Riz Rice	Non glacé Unpolished	Glacé à 50 % 50 % polished	Glacé à 70 % 70 % polished	Glacé Polished
K_2O	11.76	10.94	11.20	13.30
Na_2O	4.03	3.79	3.64	5.80
CaO	1.66	1.29	1.35	3.23
MgO	6.75	6.61	6.54	5.74
P_2O_5	73.36	75.03	75.07	69.83
SO_2	0.25	0.23	0.22	0.18
SiO_2	2.13	2.00	1.92	1.84
Fe_2O_3	0,06	0.05	0.05	0.04
Cl	+	+	+	+

The figures of Table XI are the percentage in rice.

Table XI.

Riz Rice	Non glacé Unpolished	Glacé à 50 % 50 % polished	Glacé à 70 % 70 % polished	Glacé Polished
K_2O	0.16	0.11	0.08	0.07
Na_2O	0.06	0.04	0.03	0.03
CaO	0.02	0.01	0.01	0.01
MgO	0.09	0.06	0.04	0.03
P_2O_5	1.02	0.74	0.53	0.36
SO_2	0.0035	0.0023	0.0015	0.0009
SiO_2	0.0296	0.0198	0.0134	0.0094
Fe_2O_3	0.0008	0.0005	0.0004	0.0002
Cl	+	+	+	+

Explanations of Tables X and XI.

(1) The order of quantity is P_2O_5, K_2O, MgO, Na_2O, SiO_2 and CaO.
(2) The phosphorus content in ash is over 70 per cent in the form of P_2O_5.

Next we studied the content of phosphorus in rices of different grades of polishing. The results are shown in Table XII.

Table XII.

Riz — Rice	Shōnai A	Miyagi	Niigata	Shōnai B
Riz non glacé . . . . . Unpolished rice	0.92	0.85	0.81	1.02
Riz glacé à 50% . . . . . 50% polished rice	0.73	0.81	0.68	0.74
Riz glacé à 70% . . . . . 70% polished rice	0.54	0.65	0.55	0.53
Riz glacé . . . . . Polished rice	0.40	0.52	0.43	0.36

The percentage of phosphorus compared with unpolished rice (as 100 per cent) is shown in Table XIII.

Table XIII.

Riz — Rice	Shōnai A	Miyagi	Niigata	Shōnai B	Moyenne Mean
Riz non glacé . . . . Unpolished rice . . .	100.00	100.00	100.00	100.00	100
Riz glacé à 50% . . . 50% polished rice . .	79.35	95.29	83.95	72.55	80
Riz glacé à 70% . . . 70% polished rice . .	58.70	76.47	67.90	51.96	65
Riz glacé . . . . . Polished rice	43.48	61.18	53.09	35.29	45

Explanations of Tables XII and XIII.

The amount of phosphorus in 50%-polished rice is about 80 per cent of that in unpolished rice; in 70%-polished rice it is 65 per cent, and in polished rice it is 45 per cent.

The germ of the rice kernel (the embryo of the seeds) is richest in the anti-beri-beri substance. It is suggested that the loss of the germ of the rice kernel rather than that of the outer layer is the cause of the loss of the protective power against beri-beri. The germ, the phosphorus and vitamin B are all related to each other, because, as we polish rice, the germ is gradually lost and the vitamin B content and the phosphorus content are diminished at the same time. Can we determine the grade

of polishing of rice from its phosphorus content ? To solve this problem we made an analysis of the phosphorus content of many famous Japanese varieties of rice. The results are shown in Table XIV.

Table XIV.

Variétés de riz Varieties of rice	Riz non décortiqué Unpolished rice	Riz glacé à 50% correspond à 80% de P_2O_5 du riz non glacé 50% pol. rice as 80% of P_2O_5 of unpol. rice	Riz glacé à 70% correspond à 65% de P_2O_5 du riz non glacé 70% pol. rice as 65% of P_2O_5 of unpol. rice	Riz glacé correspond à 45% de P_2O_5 du riz non glacé Pol. rice as 45% of P_2O_5 of unpol. rice
	%	%	%	%
Meijinishiki	1.360	1.088	0.884	0.612
Kameno-o	1.115	0.892	0.725	0.502
Aikoku	1.034	0.827	0.672	0.465
Meijinishiki	1.020	0.816	0.663	0.459
Shŏnai II	1.020	0.816	0.663	0.459
Shinriki	0.989	0.791	0.643	0.445
Shinriki III	0.989	0.791	0.643	0.445
Ōba	0.984	0.787	0.639	0.443
Sen-ichi	0.958	0.766	0.623	0.431
Chuseimiyako	0.953	0.762	0.619	0.429
Kameno-o	0.952	0.761	0.618	0.428
Shinriki	0.949	0.759	0.613	0.427
Teikyaku	0.929	0.743	0.604	0.418
Shŏnai I.	0.920	0.736	0.598	0.414
I-gŏ	0.908	0.726	0.590	0.409
Shinriki A	0.902	0.722	0.586	0.406
Bŏ-zu	0.889	0.711	0.578	0.400
Toyokuni	0.885	0.708	0.573	0.398
Ishijiro	0.870	0.696	0.566	0.392
Sendai	0.850	0.680	0.553	0.383
Sekitori	0.841	0.673	0.547	0.378
Omachi	0.832	0.666	0.541	0.374
Chŏsen	0.832	0.666	0.541	0.374
Niigata	0.810	0.648	0.527	0.365
Mean	0.950	0.760	0.617	0.427

That is, the mean phosphorus content in many varieties of rice in Japan is 0.950% in unpolished rice, 0.760% in 50%-polished rice, 0.617% in 70%-polished rice, and 0.427% in polished rice.

Table XV shows the phosphorus content in the commercial white rices and in the rices washed with water.

Table XV.

	Riz glacé Polished rice	Riz lavé Washed rice
	%	%
Sen-ichi (Tochigi)	0.666	0.359
Shinriki (Ehime)	0.639	0.423
Omachi (Nara)	0.614	0.372
Omachi (Kagoshima)	0.604	0.359
Shōnai (Yamagata)	0.569	0.346
Kameno-o (Yamagata).	0.566	0.385
Bōzu (Hokkaido)	0.534	0.397
Sekitori (Mie)	0.495	0.423

Commercial polished rice usually contains 0.4 to 0.5 per cent of phosphorus and washed rice contains 0.35 to 0.4 per cent.

Summary and Conclusion.

(1) We investigated the diminution in the amounts of the chemical components of rice produced by different grades of polishing.

(2) Protein is slightly diminished, while fat, ash and fibre are greatly diminished, by polishing.

(3) None of the chemical components are entirely removed by polishing.

(4) There is a great difference in the chemical composition of rices of different varieties but of the same grade of polishing.

(5) Phosphorus is an important component of rice; the amount differs greatly according to the variety of rice.

(6) Recently, the resolution that rice containing less than 0.4 per cent of phosphorus should be excluded by law from those countries in which this cereal formed the principal food-grain was recognised by the Far-Eastern Association of Tropical Medicine. There are many good reasons for recommending the use of 70%-polished rice, from both the physiological and the economical standpoint.

70%-polished rice contains about 0.5 to 0.8 per cent of phosphorus, while the polished rice on the market, especially in the cities, contains about 0.4 per cent phosphorus.

Work is now in progress concerning the chemical nature of the bran and the germ of the rice kernel. These substances are removed by polishing and are important factors in determining the nutritional value of rice.

THE RELATIVE NUTRITIVE VALUE OF VARIOUS PROTEINS CONTAINED IN JAPANESE FOOD ARTICLES.

By Umetaro Suzuki,
Yoshihiko Matsuyama and Nabetaro Hashimoto
(From the Institute of Physical and Chemical Research, Tokyo).

1. Introduction.

During the past few years we have been carrying out studies on the constituents of Japanese food articles, including proteins, fats, carbohydrates, mineral salts, vitamins, etc. In the present paper we will deal only with the protein constituents.

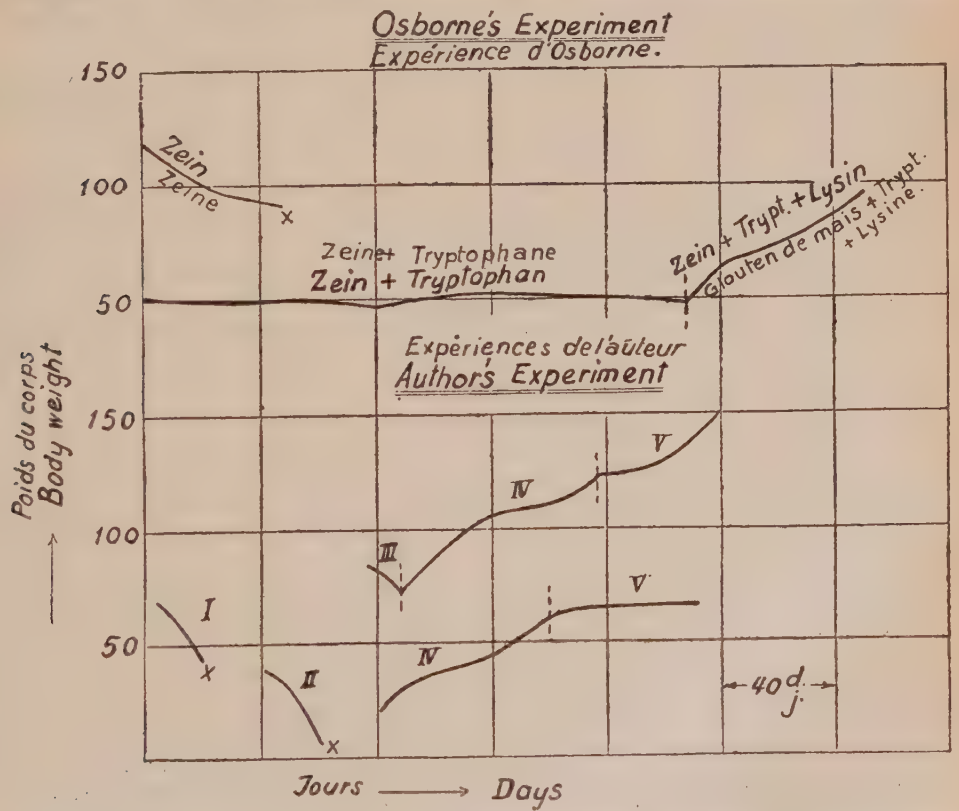


Figure I.— Experiments with zein and gelatine, showing the effect of the addition of certain amino acids to the proteins of low nutritive value.
I, II, III, gelatine; IV, V, each 0.1% cystine, tyrosine and tryptophan added; VI, tyrosine removed

Our experimental data have partly been reported in the *Journal of the Japanese Chemical Society:* Vols. XL and XLI, in co-operation with Y. Okuda, T. Okimoto, M. Iwata, K. Katakura and Z. Terada.

We employed for our experiments the method adopted by Osborne, Mendel and others, using albino rats. Feeding experiments with gelatine were made; the following diet was given: Gelatine 14 %, butter 28 %, protein-free milk 28 %, starch 30 %.

Additions of certain amino acids were made in the case of some of the animals, as will be seen in Figure I.

Curves I and II show that the rats receiving no additions died in 8 and 16 days respectively. The omission of tyrosin did not produce any remarkable effect on growth. This was probably due to the presence in gelatine of phenylalanin, which perhaps plays the same rôle as tyrosine. If either cystine or typtophane were removed from the diet growth suddenly declined, and the animals finally died.

Thus it was proved that the nutritive value of proteins can be improved by the addition of certain amino acids which may be lacking in the protein molecule.

1. Physiological Rôle of Amino Acids.

We are now faced with the question: What kinds of amino acids are necessary for the nutrition of animals? By feeding experiments it has been shown that cystine, lysine and typtophane are indispensable. Cystine is easily converted into cysteine by reduction. A peptide-like combination of cysteine and glutaminic acid (glutathione) was reported by Hopkins to be widely distributed in animal tissues, and to play an important rôle in cell metabolism. Cystine is changed to cysteinic acid by oxidation, and the latter can be converted into taurine by splitting off carbonic acid. Taurine is also widely distributed in animal tissues, and forms an important component of bile acids, *e.g.*, taurocholic acid. In feeding experiments carried out with gelatine we once administered cysteine to the rats instead of cystine and found that the former was as well utilised as the latter; cysteinic acid and taurine were unable to replace cystine.

Recently a new thio-amino acid having the formula $C_5H_{11}NSO_2$ (melting-point 272°) was isolated by J. H. Müller from the hydrolytic products of various proteins. S. Odake in our laboratory isolated the same substance from an alcoholic extract of yeast. Still another sulphur compound was obtained by us from yeast; it has the formula $C_{11}H_{15}N_5SO_4$ (melting-point 208°) and it is easily hydrolysed into adenin ($C_5H_5N_5$) and a thio-sugar ($C_6H_{12}SO_4$). The rôle of these compounds in metabolism remains to be investigated.

Recently we have fed young chickens with artificial food mixtures and have observed the beneficial effect of cystine upon the growth of their feathers and also upon the increase of their weight. Kimura obtained the same result with albino rats in his feeding experiments with " Kaoliang " (Manchurian millet). It would be worth while to test its effect upon the growth of wool.

Tyrosine and phenylalanine are closely related compounds; both contain a benzene nucleus but there is no OH group in phenylalanine. The animal body is certainly not able to synthesise the benzene nucleus, so that, if these two substances were both absent in the food, the animal could not survive. Tyrosine can, however, be replaced by phenylalanine, because the introduction of an OH group into the benzene nucleus can easily be effected in the body. Gelatine does not contain tyrosine, but, according to our experiments, rats can grow tolerably well without it. This might be

due to the presence of phenylalanin, which perhaps proved an effective substitute for tyrosine.

Lysine is diamino-capronic acid and closely resembles in its structure nor-leucine (caprin) obtained from the proteins of brain tissue by Abderhalden. Lately, it has been shown by feeding experiments that nor-leucine can replace lysine in the body. If this is true, lysine would serve for the building up of brain substance.

It would be interesting to determine whether the laying of eggs by hens is controlled by the amount of diamino acids, especially by that of lysine, contained in the food. It is quite evident that a minimum amount of these bases is required for building up egg proteins, and, if the supply is insufficient, the production of eggs must be limited according to the law of minimum.

As rabbits or rats can grow normally on a milk diet which is practically free from nuclear substances, there is no doubt that purine or pyrimidine bases can be formed from amino acids. The close resemblance of arginine and histidine to the above-named bases suggests that the latter can easily be formed from the former, but there is yet no direct proof to support this view; our animals would never grow without a supply of these two bases. A point which remains to be determined is whether histidine could be replaced by arginine or not. Mention may be made here of the fact that many hormones, such as tyramine, adrenaline and histamine are derived from tyrosine and histidine. Choline and betaine are also formed from amino acids by methylation, so that the formation of nervous tissues is indirectly dependent upon amino acids.

In the case of other amino acids than those mentioned above, it has not yet been proved whether they are essential or whether they can be replaced by others. Glycocoll is most probably not essential, while alanine and leucine can replace each other. Recently the importance of proline has been shown by B. Sure. Whether oxyproline can replace proline remains still to be settled.

If we could obtain normal growth with a ration containing a mixture of amino acids instead of protein, we should be able to determine the rôle of each amino acid more precisely, for we could observe the effect caused by eliminating any one of the amino-acids from the mixture. This kind of experiment has, however, not yet been successfully performed by any worker.

We did some experiments of this kind some years ago, employing a mixture of the following amino acids:

Glycocoll	4	Glutaminic acid . . .	15
Alanime	15	Phenylalanine	3
Leucine	20	Arginine	5
Valine	8	Histidine	5
Proline	5	Lysine	5
Cystine.	3	Tryptophane	2
Tyrosine	5	Ammonium carbonate.	2
Aspartic acid	3		
		Total.	100

(Note. — Glutaminic acid was given as the sodium salt during the first part of the experiment, but later it was given as the calcium salt. Arginine, histidine and lysine were employed in the form of the hydrochlorides.)

The above mixture was mixed with butter, starch and protein-free milk in the following proportions: Amino-acids mixture 15, butter 20, starch 36, protein-free milk 28, ca-lactate + ca-phosphore 1,

Albino rats weighing 52 to 100 grams were fed on the above ration. The animals had a good appetite at first but they did not grow at all; their body weight soon began to decline and their appetite was lost. One died in 50 days (Figure II). To another one which was about to die at the end of 47 days, horse-meat protein was given instead of the amino-acid mixture; the animal soon recovered its appetite and began to grow vigorously.

This experiment proved that the amino-acid mixture could not replace protein in the diet. The animals, however, lived longer than those fed only on water or on a protein-free ration (Figure II).

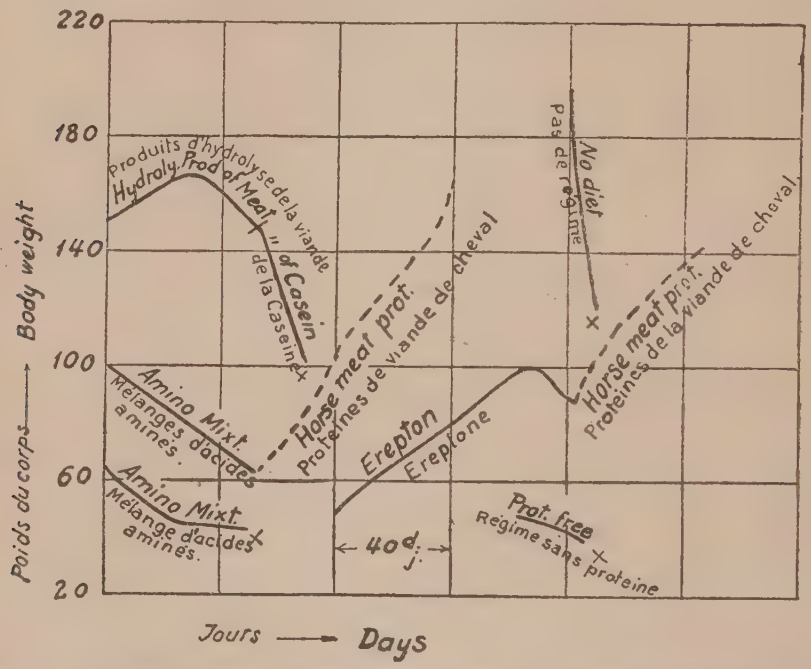


FIGURE II. — Experiments with hydrolytic products of proteins and with the mixture amino acids.

We then carried out experiments with hydrolytic products of proteins, using a mixture of two preparations obtained as follows:

(1) Horse-meat protein was boiled with 25% sulphuric acid for 12 hours and, after cooling, the sulphuric acid was carefully removed by baryta and filtered; the filtrate was decolorised with animal charcoal and evaporated to dryness.

(2) Horse-meat protein was boiled with an excess of saturated baryta solution for 60 hours, when the solution no longer gave the biuret reaction; it was filtered and, after removal of the baryta by sulphuric acid, evaporated to dryness.

The two preparations were mixed in equal proportions and sodium carbonate was added to neutralise the acidity. By boiling the meat with sulphuric acid, tryptophane and a part of the cystine were decomposed; while by treating with baryta, tryptophane was racemised, though it was not destroyed; cystine and a part of the arginine were decomposed. The mixture of the two preparations thus contained all the amino acids except cystine, and we therefore added cystine to it.

To this mixture were now added butter, starch and protein-free milk in the usual way, and this ration was given to albino rats. No good result was obtained, as is shown in Figure II.

We have obtained good results with Witte's peptone and have also tried "Erepton", a preparation imported from Germany.

Fed on a diet containing 15 per cent erepton, a rat lived more than 100 days and gained in body weight, but growth was much slower than normal (Figure II). Erepton is considered to be a mixture almost entirely composed of amino acids but containing a variable quantity of peptides. Why, then, were good results not obtained previously with the mixture of pure amino acids ? This might be due to the presence in protein of some very unstable substance, which plays an important part in nutrition. Racemisation of amino acids by the action of acids or baryta must also be a factor in producing the untoward effects. The real cause will be revealed before long and then the problem of the preparation of an artificial diet will be much simplified.

2. Nutritive Value of Proteins in Various Articles of Food.

Here we will deal with the nutritive value of proteins derived from foodstuffs in general use.

(1) *Fish Proteins.*

In Japan, fish are employed as food more extensively than in any other country, consequently it is important for the Japanese to determine whether fish flesh has the same nutritive value as the flesh of chicken or cattle. At the same time, the establishment of its nutritive value would greatly influence our future food policy. With this object in view, we carried out feeding experiments some years ago, and showed that fish proteins are as good as any other animal proteins. It must be kept in mind, however, that fish flesh contains, besides proteins, many other valuable constituents such as fats, glycogen, extractives, inorganic matters, vitamins, etc., which are indispensable for the nutrition of animals. Therefore, in comparing fish with meat, these constituents should never be excluded from our consideration. The present work has been carried out simply on proteins. There was no need to separate and purify the proteins of fish or of meat in such practical experiments as we carried out. The following procedure sufficed: the material was first triturated and boiled with water; the coagulum formed was mixed with the insoluble residue and boiled twice or three times with a large amount of water. The boiled residue was then extracted twice to three times with alcohol and ether. The remaining substance was practically pure protein, which could be powdered after desiccation. In the feeding experiments the proteins thus prepared were mixed with other substances in the proportions shown below and given to albino rats: protein 10%, butter 14%, protein-free milk 28%, starch 48%.

Generally speaking, a ration containing 10 per cent of fresh protein was sufficient to promote normal growth in young albino rats. The experiment lasted for three generations without producing any abnormal symptoms. We carried out similar experiments with milk casein, beef, horse meat, etc., as controls, and proved that fish proteins are no less nutritious than meat proteins. In another series of experiments in which the protein was reduced to 7 per cent, the animals still attained normal growth, although there were slight differences in development according to the different kinds of fish from which the proteins were prepared; thus herring, salmon, dried bonito, ligament of the escallop-shell, crayfish, crab, etc., gave nearly the same results as beef, while tunny, mackerel, shark, globe-fish, etc., gave more or less inferior results (Figure III).

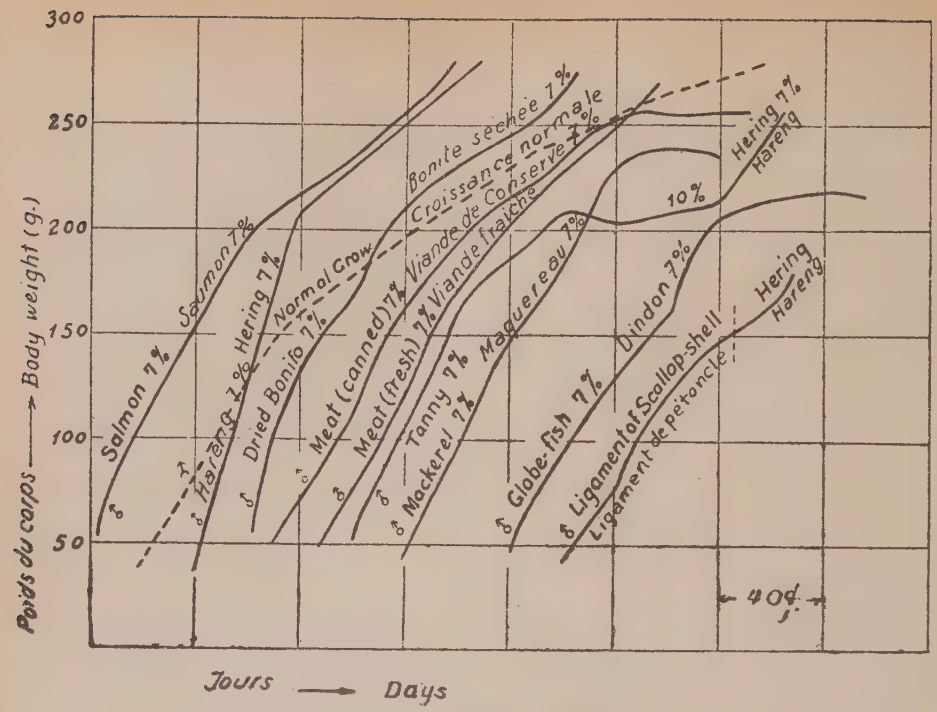


FIGURE III. — Fish proteins (7%).

For the sake of further comparison, the results of experiments with the proteins of peanut and soy-bean (whole grain) are shown in the following figure (Figure IV).

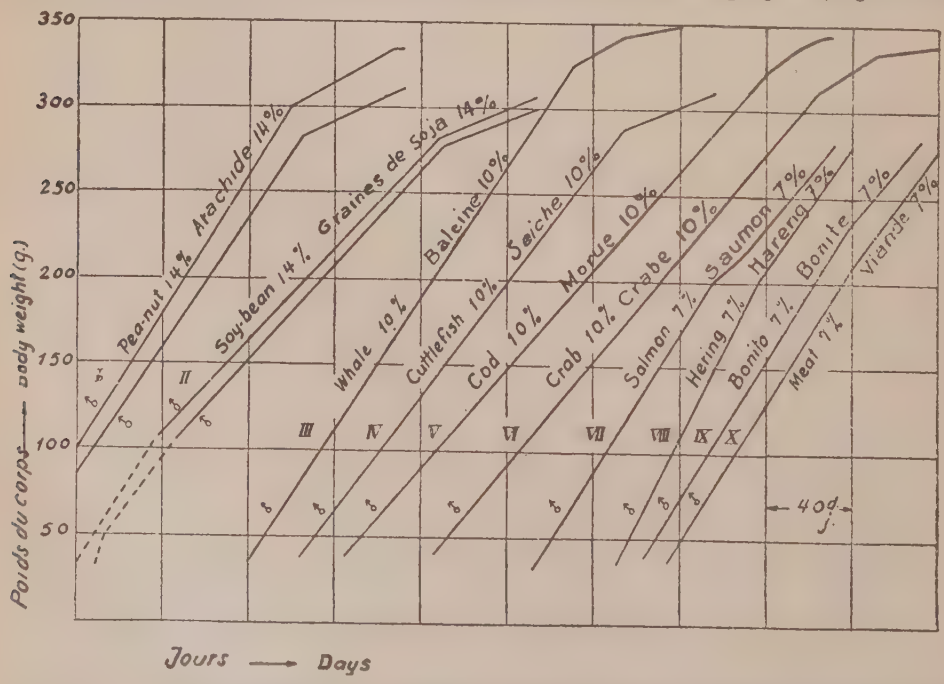


FIGURE IV. — Fish proteins (10%), compared whith peanut and soy-ban proteins (14%)

It should be noticed that the market price of fish does not necessarily correspond with their nutritive value, for the cheaper fish, such as salmon, herring, etc., may have a higher nutritive value than the dearer. The nutritive value of various fish proteins seems to be closely related to their amino-acid content, especially to that of lysine. The ligament of the escallop-shell is especially rich in lysine.

Dried fish had just the same nutritive value as fresh, and even canned fish kept for a long period had not lost any of its nutritive value as far as proteins were concerned. Some 4- to 10-year-old canned beef was presented to us by the Department of Provisions of the Japanese Army to be tested, and we could find no difference in the nutritive value of the proteins derived from the fresh sample and those from the preserved ones. The same was found with fresh and dried bonito.

(2) *Rice.*

Perfectly polished and washed rice contains about 7 per cent of proteins, 92 per cent of starch, and a small amount of fat, fibre and ash.

Polished rice contains the following amounts of the different types of protein:

Soluble in 10% sodium chloride	14.17 %
Soluble in 0.2% caustic soda solution . . .	70.90 %
Soluble in water	5.84 %
Soluble in 60% alcohol	9.17 %

If " rice-koji " is extracted with a 10% sodium-chloride solution and the extract is dialysed at room temperature, hexagonal plane crystals separate out which closely resemble the " excelsin " of brazil nut. Crystallisation takes place easily because substances such as dextrin, which prevent the crystallisation of protein, are dissolved and assimilated by fungi. Some of the proteins soluble in dilute alkali belong to this group of crystalline proteins.

The rice protein used for our experiments was prepared as follows:

Polished rice was finely powdered and mixed with a 0.2% caustic soda solution. After the mixture had stood for several hours, during which time the mixture was occasionally stirred, it was filtered through cloth. A greyish-white precipitate formed on adding dilute acetic acid to the filtrate: this was collected and washed with water, alcohol and ether successively. It was re-dissolved in a 0.2% caustic soda olution and reprecipitated. By this process about 70 per cent of the rice protein could be obtained. Amounts proportional to 10, 15 and 18 per cent of this protein (calculated as pure protein) were taken, butter and protein-free milk were added in the proportions of 18 and 28 per cent respectively and enough starch was added to make up the total to 100. These three mixtures were administered to albino rats. The results showed that rice protein was inferior to fish protein, because by giving the former to the extent of 10 per cent of the diet the rats never gained more than 130 grams. By using 12 per cent of it a better result was obtained, but normal growth seemed only attainable by employing 15 per cent or more of this protein (see Figure V).

As mentioned above, rice contains a small amount of water- and alcohol-soluble proteins. If, therefore, these proteins were added to those employed in our preceding experiments, *i.e.*, if we were to use the whole protein of rice, a better result might be expected. For this purpose we extracted the rice-flour with a 0.2% caustic soda solution and precipitated the greater part of te protein by adding dilute

acetic acid in slight excess. The filtrate therefrom was boiled to coagulate the protein remaining in solution (chiefly albumins); the coagulum was added to the first precipitate; the starch adhering to the protein was removed by means of diastase and the whole was again dissolved and precipitated in the way mentioned above. By this process we could collect the greater part of the proteins, including the water- and alcohol-soluble ones.

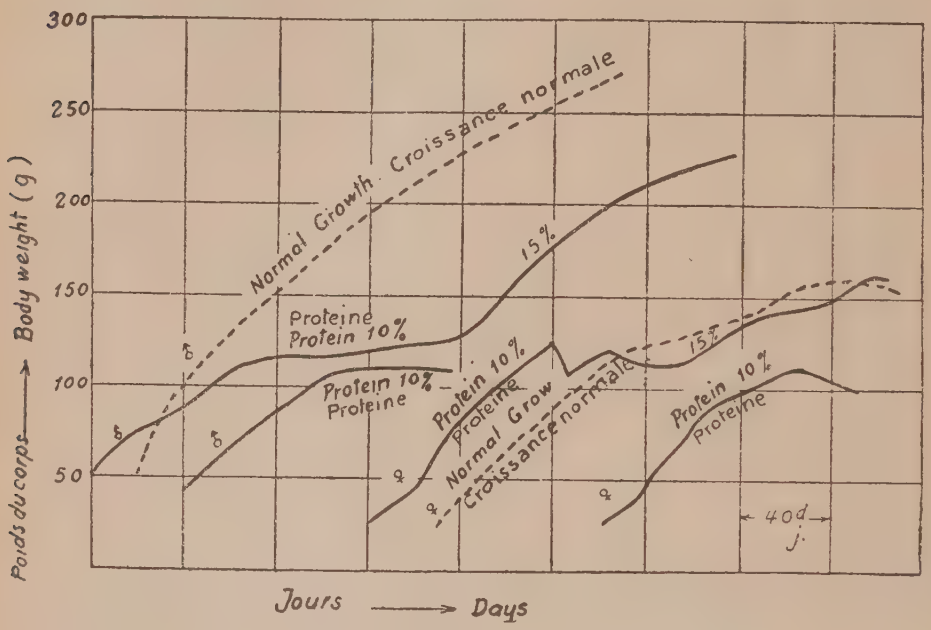


FIGURE V. — Experiments with rice protein extracted with dilute alkali.

The diet for our feeding experiments was prepared by mixing together 48 per cent of rice-flour, 14 per cent of butter, 28 per cent of protein-free milk and 10 per cent of the proteins obtained in the manner above described.

This diet gave fairly good results, but it was still somewhat inferior to the one that had contained 7 per cent of the proteins of salmon or herring, etc. (see Figure VI). Protein prepared from unpolished rice instead of polished rice gave somewhat better results because the bran and the embryo contain proteins of better quality than are found in polished rice.

It will be seen from Figure VII that the rats fed on a ration containing 12 per cent of rice protein gradually gained in body weight until they reached a maximum of 300 grams, but with 10 per cent of protein they attained the same body weight only when 1 per cent of calcium carbonate was added to the diet; on the whole, however, normal growth was not secured with 10 per cent of rice protein. One of the rats fed on a mixture containing tryptophane reached the weight of 377 grams; the others, however, did not exceed 300 grams. Generally, the addition of calcium tryptophane and cystine had some beneficial effect upon the growth, but the amino acid which controlled the growth in this case was probably lysine. These points remain still to be examined in detail. We may conclude from these experimental data that 10 per cent of rice protein is nearly equal or is a little inferior to 7 per cent of fish proteins (Figure VII).

When the rats were fed on a ration containing 2 per cent of beer-yeast besides butter and protein-free milk, the amount of rice protein required for producing normal growth was 8.5 per cent. With 6.5 per cent of rice protein and 2 per cent of either fish or horse-meat protein, the rats also grew very well (Figure XI).

The addition of a small amount of milk, meat, egg or fish protein gives decidedly better results than does the addition of more of the rice protein. We carried out a series of experiments to determine the minimum amount of various proteins required for the maintenance of fully-grown albino rats. With meat, milk and fish proteins, etc., the minimum was found to be 5 to 6 per cent, while with rice protein it was about 7 per cent.

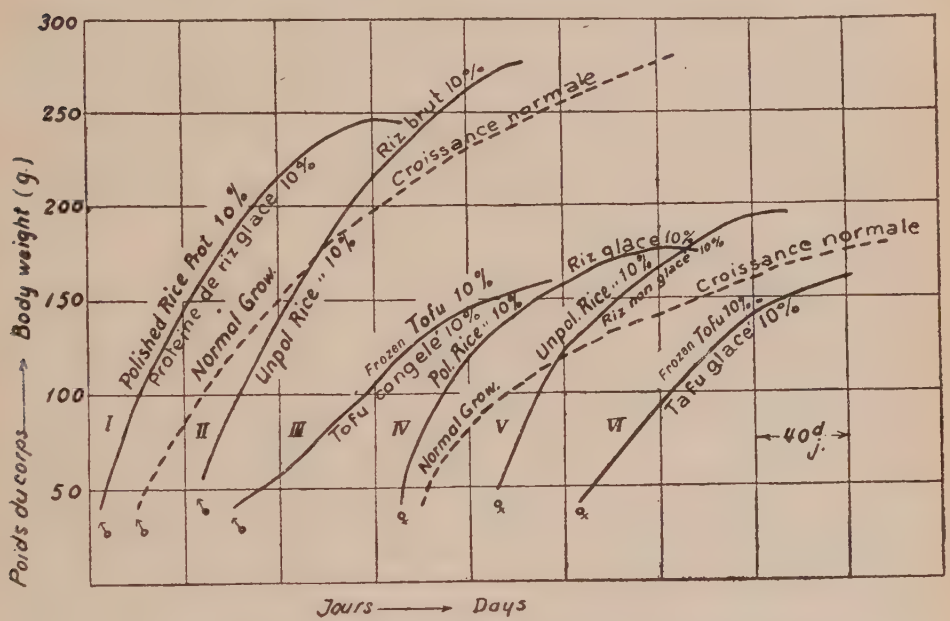


FIGURE VI. — Experiments with rice and tōfu proteins.

Rice-flour mixed with protein-free milk and butter and supplemented with rice protein up to 10 per cent.

The rice embryo is very small and is almost entirely removed during the process of polishing. It is rich in protein, fat, sugar and vitamins. M. Hamada analysed a refined sample of rice embryos, the so-called "menzai", which was supplied by the "Time" Rice-Polishing Factory. This sample contained approximately 70 to 80 per cent of pure embryos. The results of his analysis were as follows:

	%
Crude protein	23.0
Protein	19.5
Fat	23.0
Fibre	11.1
Starch, sugar, etc.	30.9
Ash	11.4

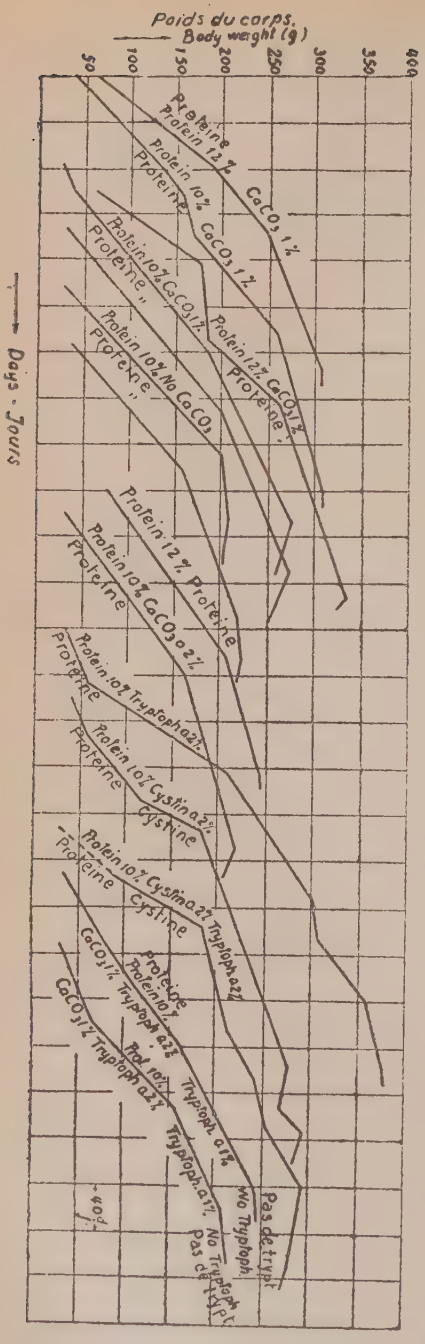


FIGURE VII. — Experiments with the whole protein of polished rice.

He isolated the protein from "menzai" and estimated the amino nitrogen by hydrolysis. The results were as follows:

	%
Monoamino nitrogen . . .	54.44
Diamino nitrogen	36.68
Arginine nitrogen	20.04
Histidine nitrogen	5.72
Lysine nitrogen	9.12
Cystine nitrogen	0.681

It will be seen that the embryo contains nearly as much protein as does meat. The lysine content was just twice as great as that of polished rice, so that a high nutritive value might be expected for the embryo protein. Feeding experiments proved this to be true. If our results are compared with those of Osborne obtained with wheat embryo protein, it is seen that rice embryo protein is better than wheat (Figure VIII).

(3) *Wheat.*

Wheat meal supplied for human consumption consists chiefly of the perisperm, which contains about 11 per cent of protein. The largest portion of this protein consists of alcohol-soluble gliadin and glutenin, which are commonly known by the name gluten.

The refined preparation of gluten does not suffice to promote growth in animals, nor does wheat-flour protein. When given even in large amounts to rats only slow growth occurs. When, however, 2 per cent of meat protein is added to 6 per cent of the wheat protein, tolerably good growth is attained. When about one-third of the total protein in a given ration was replaced by either egg albumin or milk or meat protein, more satisfactory growth was attained. Ten per cent of such mixed proteins gave far better results than 15 per cent of the wheat protein alone.

In experiments carried out by the authors, animals fed with a ration containing 7 per cent of gluten did not increase in weight beyond 150 grams. When 0.35 per cent of diamino acids prepared from the semen of the salmon was added to the above ration, somewhat better growth was obtained. Good growth could be obtained by giving a ration containing 14 per cent of gluten and 0.7 per cent of diamino acids, but growth stopped when the ration was changed to 7 per cent of gluten without any admixture of the semen preparation. The chief cause of the

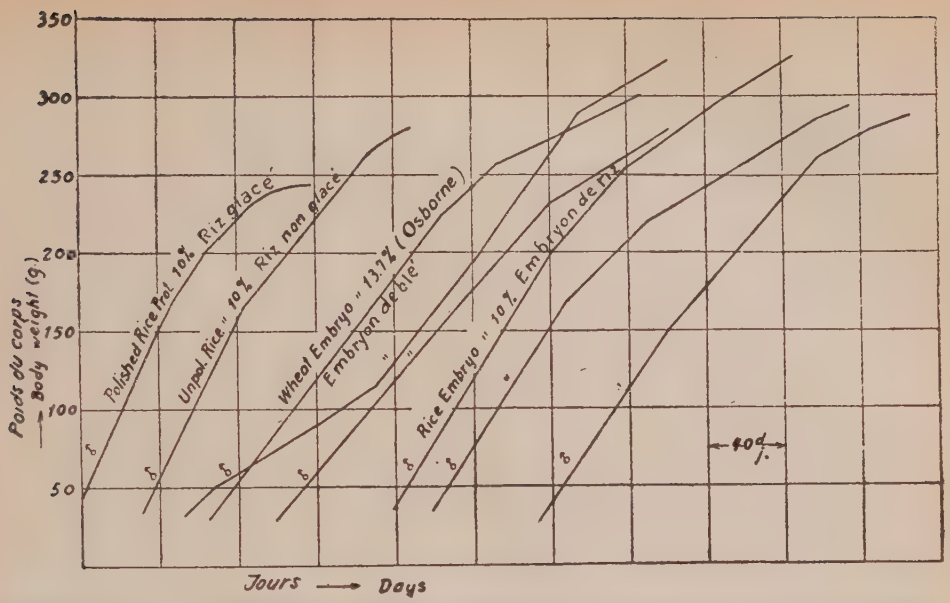

Polished Rice Prot. 10% Riz glacé
Unpol. Rice " 10% Riz non glacé
Wheat Embryo " 13.7% (Osborne)
Embryon de blé " "
Rice Embryo " 10% Embryon de riz
40 d.
Poids du corps — Body weight (g.)
Jours — Days

FIGURE VIII. — Rice embryo protein compared with wheat embryo and rice protein.

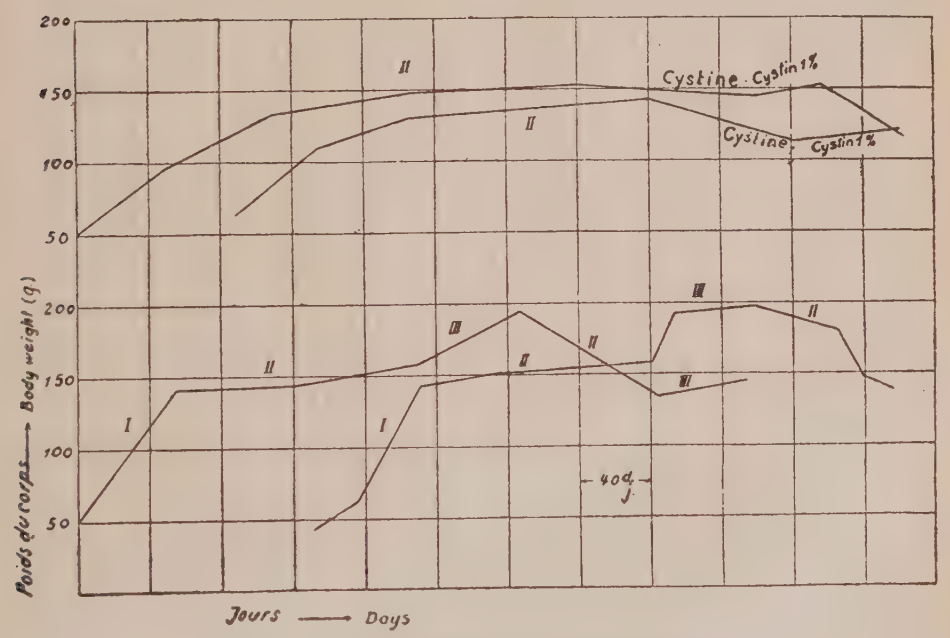


FIGURE IX. — Experiments with wheat gluten.

I	Gluten	13.3%	II	Gluten	7%	III	Gluten	6.6 %
	Diamino acids	0.7%		Butter	14%		Diamino acids	0.35%
	Butter	14.0%		Starch	51%		Butter	14.0 %
	Starch	44.0%		Prot.-free milk	28%		Starch	51.0 %
	Prot.-free milk	28.0%					Prot.-free milk	28.0 %

low nutritive value of gluen has been proved to be its remarkably low content of lysine and tryptophane (Figure IX).

From the whole grain of wheat a better mixture of proteins is obtained than from wheat-flour, *i.e.*, the nutritive value of the former is found to be higher than that of the latter. Proteins from the whole-wheat grain would serve as a maintenance ration as well as casein does and, if given in sufficient quantity, could produce normal growth (see Figure X).

It should be noticed here that in America there is a movement to make the public use wheat-flour from which as little bran as possible has been removed, just as there is a movement in Japan to encourage the use of either unpolished rice or half-polished rice. From the point of view of the economical use of proteins,

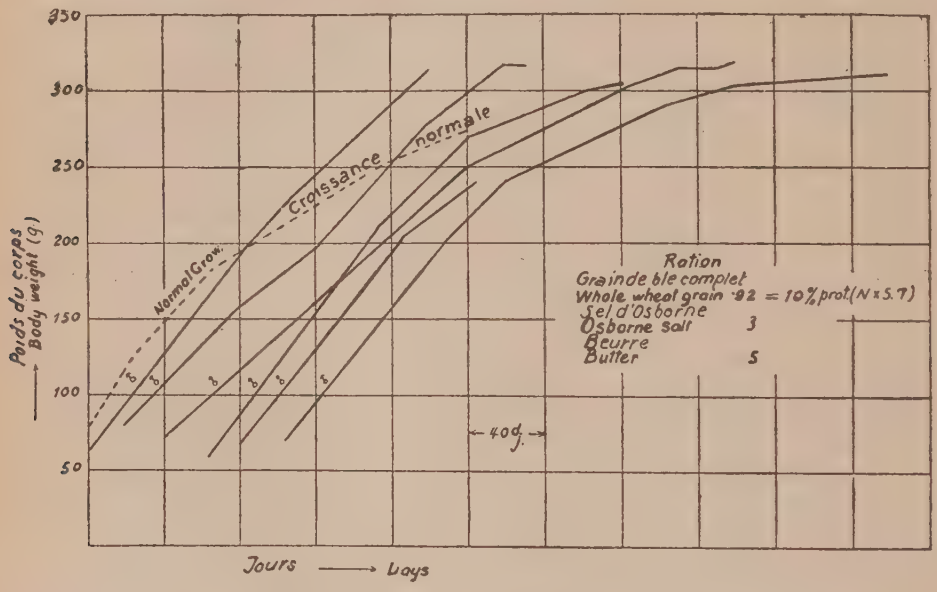


FIGURE X. — Experiments with whole-wheat protein (after Osborne).

these movements are rather irrational, because the admixture of only a small amount of meat or milk gives better results. Bran should be fed to domestic animals and the milk or meat from them should be used for human food. Bran contains no fat-soluble vitamin, although it is rich in water-soluble vitamin, and therefore it is advisable to keep it for cattle and give milk and meat to man. In the case of rice, a further point must be considered; when perfectly polished, it is entirely free from any water-soluble vitamin, and its use would lead to a dangerous B-avitaminosis; the use of half-polished rice could, however, be safely recommended. The use of half-polished rice may promote the utilisation of certain inorganic substances, but it is of no great importance from the point of view of the utilisation of proteins.

The authors fed young albino rats with a ration consisting of bread to which had been added 2 per cent of beer-yeast, 10 per cent of butter, 18 per cent of Osborne's salts, and 0.2 per cent of calcium carbonate, with sufficient starch to make a total protein content of 10 per cent. With this ration the rats attained just the standard growth. It was also found that a ration containing 6.5 per cent of either bread, wheat or rice protein and 2 per cent of meat protein was adequate for tolerably good growth (Figure XI).

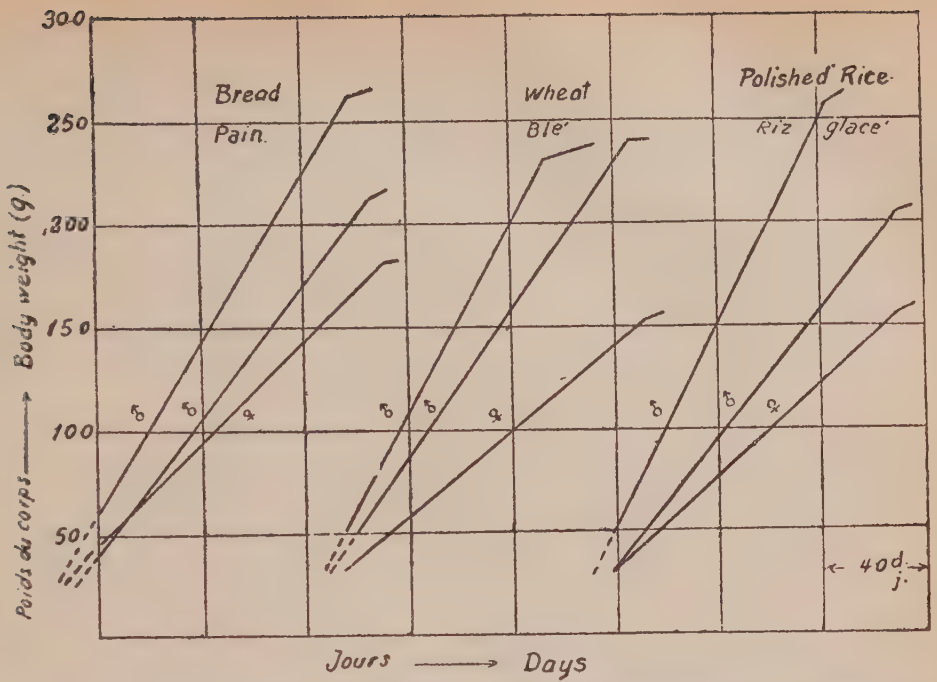


FIGURE XI. — Showing the good growth of rats by supplementing 2% of meat protein to the diets, containing each 6.5% of bread, wheat and polished rice protein.

(4) *Soy Bean.*

The chief protein contained in the bean is glycinin, which is soluble in dilute alkali. The protein found in " tofu " (bean curd) consists almost exclusively of this sort of protein; Besides this the bean contains a small amount of water-soluble and alcohol-soluble protein.

The amount of diamino nitrogen in the bean protein is as follows:

Glycinin 3.95 %, " tofu " protein 4.65 %, frozen " tofu " protein 4.47 %.

The distribution of diamino nitrogen expressed as a percentage of the total nitrogen of the bean protein is as follows:

Table III.

	Arginine nitrogen	Histidine nitrogen	Lysine nitrogen	Analyser
Bean protein (whole grain) .	62(?)	2.60	7.02	Grindley
White bean (whole grain) .	12.67	5.77	6.14	Grindley
" Tofu " protein	13.09	6.87	9.03	Kimura
Frozen " tofu " protein . .	15.85	3.66	8.38	Kimura
Glycinin.	14.18	3.26	3.72	Grindley
Glycinin.	15.30	2.38	10.27	Jones and Waterman

The figure for the lysine nitrogen of glycinin obtained by Grindley seems to be too low. Perhaps that of Johns and Waterman is more reliable.

The lysine content of bean protein lies between that of rice and meat proteins and is much greater than that of wheat or other vegetable proteins. The nutritive value of bean protein seems, therefore, to be high. Osborne carried out feeding experiments with the raw, boiled and steamed bean as well as with bean-flour. In the case of the raw bean, growth was much slower than in the case of the cooked bean.

The bean contains more or less fat soluble vitamin and the rats eating it grew well even when no butter was added, though the addition of butter produced more satisfactory growth. The authors showed that the bean oil, unlike other plant oils, contained a comparatively large amount of fat-soluble vitamin.

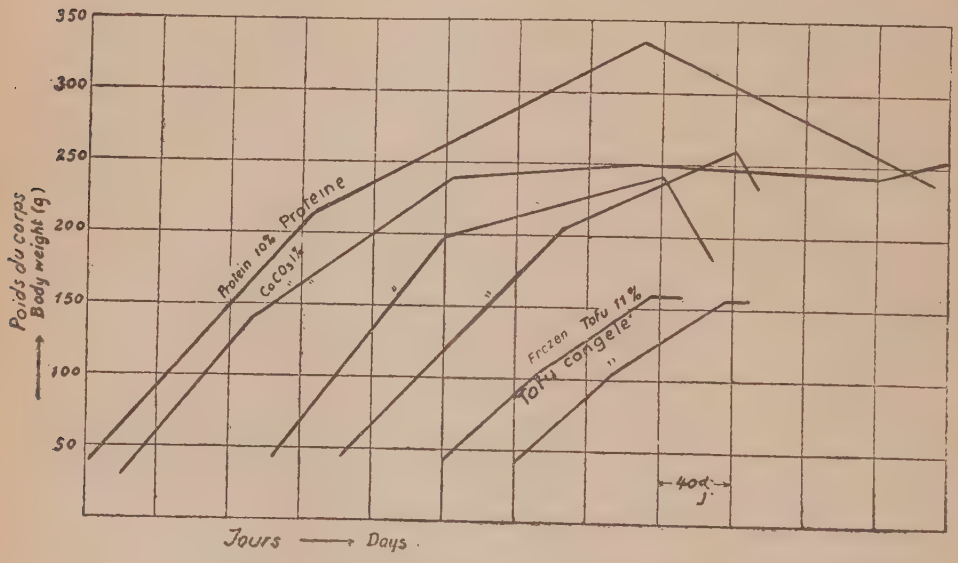


FIGURE XII. — Experiments with "tōfu" protein

M. Koyama carried out feeding experiments in the author's laboratory with a ration consisting of fat-free bean-flour, butter, starch and protein-free milk; the protein content of the mixture was 14 per cent and was sufficient for normal growth (see Figure IV, comparison with fish proteins.)

" Tofu " has a somewhat lower nutritive value than the whole bean because it does not contain the water-soluble protein of the bean. The authors dried " tofu ", reduced it to a powder, removed the fat and added butter, starch and protein-free milk so that the total mixture contained 10 per cent of protein; the results of the feeding experiments with this ration are shown in Figure XII.

The authors fed albino rats with the following mixture: polished rice 80 per cent, " tofu " 17 per cent, Osborne's salts 2.8 per cent, calcium carbonate 0.2 per cent and a small amount of oryzanin, making the total protein content of the mixture 10 per cent. It did not give satisfactory results; the rats did not exceed 130 grams in weight. When 5 per cent of butter was added to the ration, they began to grow vigorously. This means that the protein was not inadequate but the ration lacked

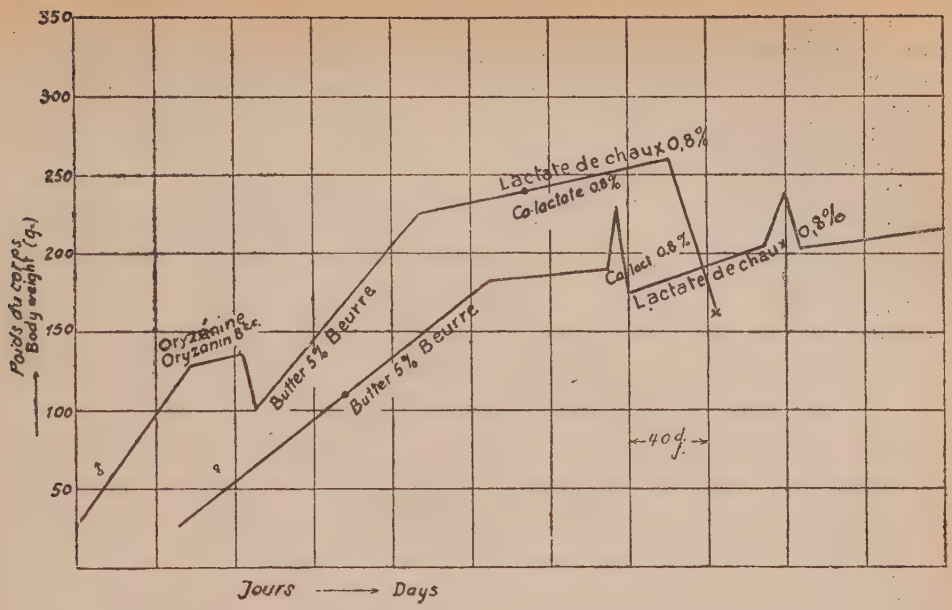


FIGURE XIII. — Showing the moderately good growth with the ration consisting of 80% polished rice and 17% tofu, when 5% butter was added to it.

the proper amount of fat-soluble vitamin (see Figure XIII). It should be pointed out that " tofu " contains a large amount of magnesium, so that the growth of the animals would be markedly interrupted unless a suitable amount of calcium was added to the ration.

(5). *Kaoliang (Andropogon sorghum Brot).*

J. Kimura analysed kaoliang seedwith the following results:

	Polished kaoliang	
	% of air-dried substance	% of dry substance
Water	9.23	—
Crude fibre	1.32	1.43
Crude fat	2.08	2.29
Non-nitrogenous substance	78.12	83.86
Crude protein	10.19	11.23
Ash	1.05	1.16
Total nitrogen	1.63	1.80
Protein nitrogen	1.60	1.76
Non-protein nitrogen	0.03	0.04

Almost all of the nitrogen is in the form of protein, the total amount of the latter being almost equal to that of wheat. Although there are variations according to the varieties and to the degree of polishing, kaoliang protein contains, on the average, 4.4 per cent of water-soluble protein, 1.67 per cent of protein soluble in 10% sodium chloride, 59.4 per cent of protein soluble in a 0.2% caustic soda solution and 34.6 per cent of other protein. When kaoliang is extracted with 70% alcohol at 70° C, 48.3 per cent of the total protein is dissolved, *i.e.*, nearly one-half of the protein belongs to the prolamin group as does gluten obtained from wheat; most of the rest is alkali-soluble. Johns and Jones gave the name " kafirin " to the alcohol-soluble protein of kafir.

Kimura hydrolysed kaoliang protein by hydrochloric acid and determined the distribution of nitrogen by Van Slyke's method; he obtained the following results:

	Alcohol-soluble protein (% of total nitrogen)	Whole kaoliang protein (% of total nitrogen)
Humin nitrogen	0.28	1.05
Ammonia nitrogen	21.28	16.05
Histidine nitrogen	3.67	2.39
Arginine nitrogen.	4.26	5.02
Lysine nitrogen	4.53	2.96
Cystine nitrogen	0.14	0.11
Monoamino nitrogen	64.86	63.78

We have calculated from the above results that, for every 100 parts of alcohol-soluble protein, there is 1 part of arginine, 1 part of histidine and 3.4 parts of lysine. Johns and Jones analysed " kafirin " and found: arginine 1.6 per cent, histidine 1.0 per cent and lysine 1.9 per cent. The lysine content obtained by them seems to be too small.

Kimura fed albino rats with a ration consisting of the following mixture: polished kaoliang 92.4, butter 14.2, Osborne's salts 2.8 and calcium chloride 0.2. The mixture contained 9.5 per cent of protein, 14 per cent of fat, 72.5 per cent of carbohydrate and 4 per cent of ash. The rats grew very slowly and did not exceed 150 grams in body weight; the addition of 1 per cent of diamino acids prepared from horse meat, together with a small amount of cystine and tryptophane, caused a sudden increase in body weight. By removing the additional substances from the ration, growth was again retarded (see Figure XIV).

As will be seen from the analytical results, the amounts of arginine, histidine and lysine in kaoliang protein are very small, which explains why kaoliang is inadequate for the normal growth of rats. The amount of cystine is also insufficient for the growth of rats; this was shown by the bad development of their hair. By adding a certain amount of cystine, the growth and lustre of the hair were greatly improved. Thus the nutritive value of kaoliang protein seems to lie just between that of wheat and rice.

It must be mentioned that kaoliang is almost entirely lacking in fat and fat-soluble vitamin, although it seems to contain more or less water-soluble vitamin; considering that the addition f ocryzanin caused better growth, it might be supposed that the amount of the latter was inadequate (see Figure IV No. 1). The addition of calcium to the ration produced a better result.

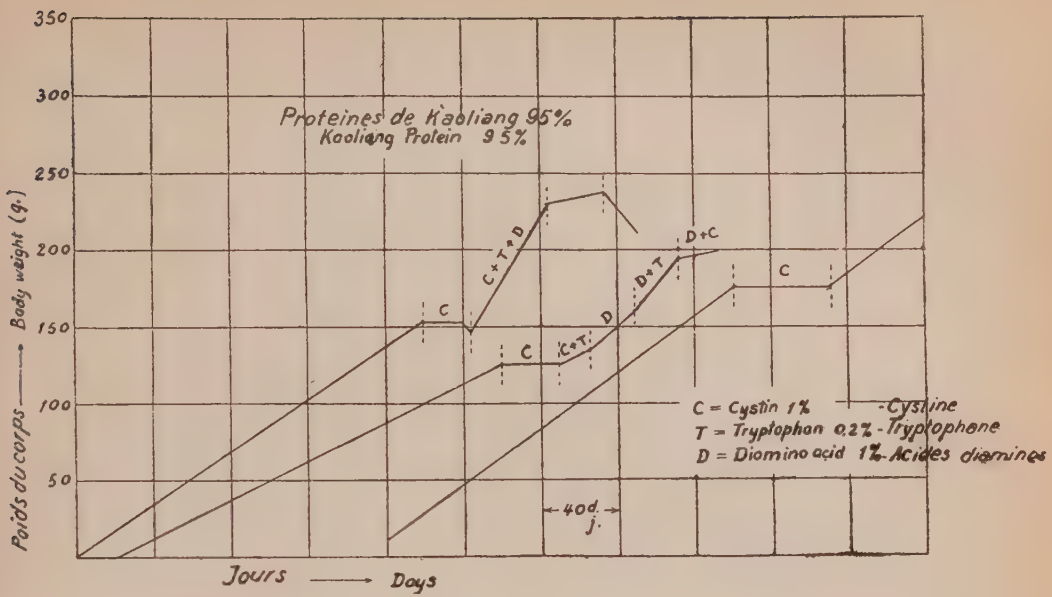


FIGURE XIV. — Kaoliang protein (Kimura.)

(6) *Oats.*

The authors carried out experiments with oatmeal such as is used for human consumption; the rations were as follows:

Table IV.

	1 (Protein 10%)	2 (Protein 8%)	3 (Protein 5%)
Oatmeal	70.0	57.0	35.5
Osborne's salts	3.0	3.0	3.0
Butter	5.0	5.0	5.0
Starch	22.0	35.0	56.5

The rats fed on rations 1 and 2, containing 10 per cent and 8 per cent of protein respectively, attained almost standard growth, but those taking ration 3 containing 5 per cent of protein grew very slowly. It appears that the nutritive value of oats is nearly equal to that of barley. They contain a sufficiency of vitamin B, but are deficient in calcium, and therefore the addition of a small amount of the latter would give a better result.

7. *Rye.*

Using the flour of whole-rye grain, the following rations were prepared:

Table V.

	1 (Protein 10%)	2 (Protein 8%)	3 (Protein 5%)
Rye flour	80.0	64.0	40.0
Osborne's salts	3.0	3.0	3.0
Butter	5.0	5.0	5.0
Starch	12.0	28.0	52.0

Rats fed on ration 1 seldom reached the weight of 200 grams, and most of them died in four to five months. Of those taking ration 2, some reached 200 grams, but most of them died. The results with ration 3 were almost the same as those with barley and oats, but with the former there was a higher mortality. These results may have been due to deficiency either of calcium or of water-soluble vitamin. Further investigations must be made on this point.

8. *Peanut.*

The dried peanut, analysed by T. Shiba in the author's laboratory, had the following composition in 100 parts of dry matter:

Crude proteins 32.18, crude fat 47.66, crude fibre 4.60, nitrogen-free extract 11.36, crude ash 4.20, total nitrogen 5.15.

In 100 parts of peanut protein there were 6.9 parts soluble in water, 64.6 parts soluble in 10 per cent sodium chloride, 24.9 parts soluble in dilute alkali, 0.9 parts soluble in alcohol and 4.8 parts in the residue.

Of the total proteins, more than two-thirds are soluble in 10 per cent sodium chloride. Taking advantage of the difference of their solubilities, they may be separated into arachin and conarchin. Johns and Jones analysed the peanut proteins and their results are given in the first two columns of the following table; in the third column are the results of T. Shiba (total protein nitrogen = 100).

	Arachin	Conarachin	Total protein of peanut (by T. Shiba)
Amido nitrogen	11.81	11.08	—
Cystine nitrogen	0.74	0.75	0.90
Histidine nitrogen	2.78	2.72	5.04
Monoamino nitrogen	53.30	50.23	—
Humin nitrogen	1.00	0.78	—
Arginine nitrogen	23.77	25.78	25.29
Lysine nitrogen	5.22	6.35	4.15
Non-amino nitrogen	1.65	1.94	—

We see from the above table that peanut protein is especially rich in arginine; histidine and lysine are also found in fairly large quantities. Shiba prepared a fat-free powder from peanuts and mixed it with butter, protein-free milk and starch in the following proportions: protein 14 per cent, butter 14 per cent, protein-free

milk 28 per cent and carbohydrates 44 per cent. Two albino rats were fed on this ration for six months and grew at a normal rate reaching 320 grams (see Figure IV). It was noticed that, even with a smaller amount of the protein, standard growth might be expected; peanut protein seems therefore to be better than rice protein. Peanuts, however, contain no vitamin A, though vitamin B is present in small amounts.

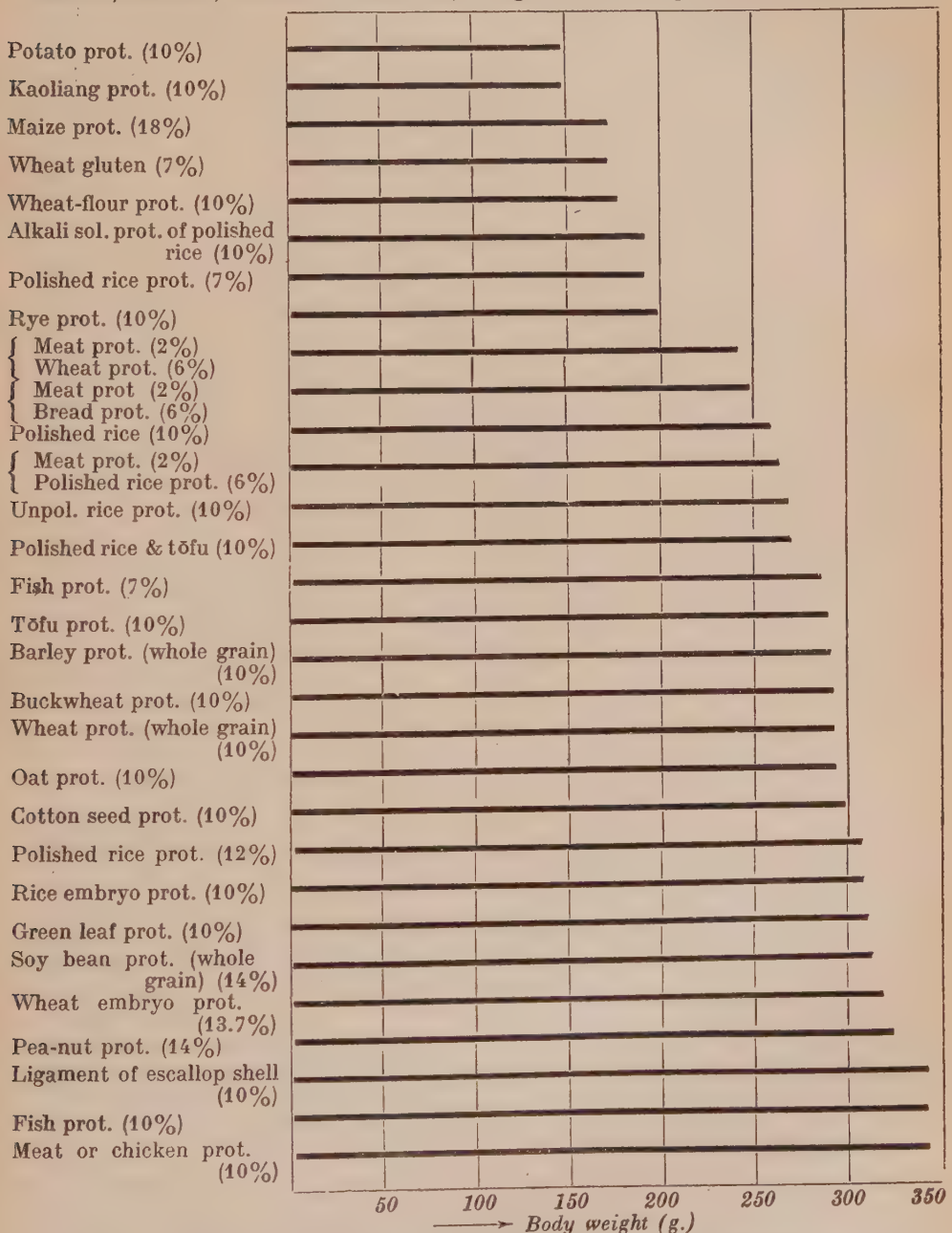


Fig. XV. — Relative Nutritive Value of Various Proteins.
Showing the maximum body weight attained by albino rats, fed on rations containing different proteins, the other factors being exactly the same.

Indian corn, barley, cotton seed, banana, potato, green leaves, etc., have been examined by Osborne, Mendel and others with regard to their chemical composition and the nutritive value of their proteins.

Figure XV has been prepared to show clearly the comparative nutritive value of various kinds of protein described above. The development of animals is influenced by various other factors than mere nutriment, for instance, individual differences, atmospheric temperature, diseases, etc., and therefore the diagram probably requires certain corrections which could only be made by repeating the experiments under identical conditions. Only a general idea of the comparative nutritive value of the proteins is therefore obtained from the diagram.

3. The Nutritive Value of Proteins and Its Relation to the Amino-Acid Content.

The authors tried to find out the relation between the nutritive value of various proteins and their amino-acid content from the results already obtained during their experiments. At present it is almost impossible, owing to the difficulty of estimating all the amino acids quantitatively. The estimation of diamino acids, *i.e.*, of arginine, histidine and lysine, can, however, be made with comparative accuracy, so we shall confine ourselves to the consideration of these three amino acids. The following table shows the distribution of the total diamino nitrogen in various kinds of protein:

Rice protein	17.69	5.39	4.90	(Osborne).
Polished-rice protein	17.21	6.25	3.70	(Kurosawa).
Rice-bran protein	18.05	5.85	5.41	(Kurosawa).
Wheat	7.99	1.67	2.47	(Grindley).
Wheat	12.53	3.84	4.04	(Grindley).
Hordenin (barley)	7.61	5.57	0.51	(Grindley).
Gliadin (wheat)	5.71	5.20	0.76	(Grindley).
Barley	9.46	3.64	2.19	(Grindley).
Arachin (peanut protein)	23.77	2.78	5.22	(Johns, Jones).
Globulin	8.34	4.23	2.80	(Johns, Jones).

The figures shown above may not all be very accurate, but all of them have been obtained by the most recent methods and we believe that the errors are not great.

It will be seen that fish proteins generally contain about the same amounts of diamino acids as those of beef, chicken, etc. The proteins of polished rice, rice bran, tofu, frozen tofu, etc., contain nearly the same amounts of diamino acids as fish proteins, while zein, hordenin, gliadin, etc., are exceedingly poor in them, which fact coincides with their low nutritive value.

The lysine content seems to bear a still closer relation to the nutritive value than the total diamino-acid content. Animal proteins are generally very rich in lysine, which represents about 10 per cent of their total nitrogen, while rice protein contains about one-half of this amount. Far smaller quantities of lysine are found in barley and wheat proteins.

Although various methods have been proposed for the quantitative determination of tryptophane in the protein molecule, none of them is generally accepted as reliable. Matsuyama and Mori, in our laboratory, modified the Rose-Herzfeld method and found it to be tolerably accurate in the case of different proteins. This method is as follows:

0.1 g. of the sample is put into an Erlenmeyer flask, 20 c.c. of 0.2% caustic soda solution are added and the mixture is warmed on the water bath at 40 to 50° C.; when the sample is completely dissolved the solution is cooled and 100 c.c. HCl (1 : 1) and 1 c.c. Ehrlich's reagent (5 g. p.-dimethylamino-benzaldehyde dissolved in 100 c.c. of 10% sulphuric acid) are added to it and the whole is kept for 24 hours at 35° C. and then for 24 to 40 hours at room temperature. The blue colour developed is compared in a Dubosque's colorimeter with that of a standard solution prepared by treating pure casein exactly in the same way as above. The tryptohane content of pure casein is taken to be 1.5 per cent.

The results obtained with more than 20 different proteins are as follows:

Mucin	—	0	0
Gelatine	0	0	0
Globulin	—	1.62	1.52
Soy-bean protein	—	0.82	—
Rice protein	—	1.33	—
Corn protein	—	trace	—
Kaoliang protein	—	—	0.40
Edestin	1.40	1.40	1.40
Legumin	1.05	0.94	0.67
Conglutin	—	1.45	1.28
Phaseolin	0.80	—	—
Gluten (wheat)	—	1.00	0.95
Gluten (corn)	1.08	—	—
Zein	0	0	0
Buckwheat protein	—	0.68	0.83
Pine-seed protein	—	0	trace
Gliadin	1.14	—	—
Glutenin	1.68	—	—
Glycinin	1.65	—	—
Casein	1.50	1.50	1.50

We see from these results that vegetable proteins contain generally less tryptophan than animal proteins, but there are many exceptions, so that the nutritive value does not always go in parallel with this amino acid.

It should be kept in mind, however, that many other amino acids, such as cystine, proline, etc., are equally indispensable for the nutrition of animals and that many new amino acids have been discovered in recent times, which would certainly be related to nutrition.

Recently, the investigations of Sadikow and Zelinsky, Troensegaard, Shibata and others have thrown doubt upon the existence of amino acids in the peptide form in the protein molecule. We may perhaps in the future be compelled to modify our present conception of the constitution of proteins and we shall then have to revise the whole problem of nutrition in the light of our new knowledge.

16.

CHEMICAL PROPERTIES AND NUTRITIVE VALUE OF THE PROTEIN OF ITALIAN MILLET *(Setaria italica, KTH).*

By Mitsuyuki Kondo

(From the Imperial State Institute of Nutrition, Tokyo).

In our country Italian millet is an important cereal ranking next to rice and wheat. In spite of this fact, I can find no reports of any detailed investigation of the properties and nutritive value of its protein. I therefore undertook the following experiments.

The material used for these experiments was Italian millet seed, which was polished by the polishing machine of the Institute and then powdered.

Analysis of its constituents gave the following results:

	Percentages in air-dried matter	Percentages in dry matter
Moisture	13.57	—
Crude protein	11.12	12.87
Protein	10.36	11.98
Crude fat	5.32	6.16
Nitrogen-free extract	63.78	73.79
Crude fibre	1.71	2.01
Crude ash	0.87	1.01

1. Solubility of Proteins.

Separation of proteins. — Before separating the proteins, their solubility in different solvents was examined. As solvents, distilled water, 10% saline solution, 0.2% alkaline solution, and 70% alcohol were used. The procedure was as follows:

15 gr. of the sample were agitated with about 800 cc. of distilled water for 24 hours at room temperature. After filtering and washing, the filtrate was made up to 1 litre. The residue was treated with 10% saline solution, 0.2% alkali solution

and 70% alcohol successively in the same way. The albuminous nitrogen was determined in each of the four filtrates.

	Dry matter %	Total Nitrogen %
Total N	1.98	100.00
Water soluble N	0.37	21.85
10% saline solution soluble N	0.43	25.48
0.2% alkali solution soluble N . . .	0.52	30.15
70% alcohol solution soluble N . . .	0.96	56.21

I repeated the extractions at a higher temperature, using the same solvents, but applying them directly to fresh samples, and obtained the following results:

Sample (gr.)	Total Nitrogen (gr.)	Solvent (200 c.c.)	Temp.	Time (hours)	Nitrogen extracted (gr.)	%
3.06	0.0544	Water	40° C	5	0.0228	41.91
2.64	0.0469	10% saline solution	40° C	5	0.0114	24.48
3.81	0.0678	0.2% alkali solution	40° C	5	0.0275	40.62
2.32	0.0413	70% alcohol solution	60° C	5	0.0209	50.60

It is evident that the proteins of Italian millet consist mainly of 70% alcohol-soluble protein and 0.2% alkali-soluble protein; the author proceeded to separate these two proteins.

2. The Separation of the Alcohol-soluble Protein.

300 gr. of the sample were heated with five times their weight of 70% alcohol in a triple-necked flask, agitated for 6 hours at 60° C. and immediately filtered. A yellow filtrate was obtained which was concentrated in vacuo, the greater part of the alcohol being thus removed. The residue was poured into cold water; the protein was precipitated as a yellow viscous mass. After filtering, the precipitate was washed with water, dried, powdered and washed with ether; 18 gr. of nearly pure protein were obtained.

3. The Separation of Alkali-soluble Protein.

350 gr. of the sample were mixed with four litres of 0.2% NaOH solution, agitated for five hours at room temperature and allowed to stand for a few hours. The mixture was then passed trough a centrifuge and the supernatant fluid was removed and neutralised with acetic acid. The precipitate thus formed was filtered and again dissolved in an alkali solution and the above treatment was repeated. After washing with water, alcohol and ether and drying, 20 gr. of protein were obtained.

The Nitrogen Distribution in Italian Millet and in the Alkali-soluble Protein and Alcohol-soluble Protein obtained from it.

(1) *The Nitrogen Distribution in Italian Millet.*

The nitrogen distribution among the seven groups of amino acids was determined directly by the Van Slyke method with the following results:

	Dry matter %	Total nitrogen %
Total N	2.033	100.00
Hot 20% HCl soluble N	1.958	96.29
Hot 20% HCl insoluble N	0.075	3.71
Humin N	0.052	2.54
Amide N	0.244	12.03
Phosphotungstate N	0.605	29.78
Cystine N	0.045	2.21
Arginine N	0.197	9.71
Histidine N	0.240	11.81
Lysine N	0.123	6.05
Amino N	0.508	25.02
Non-amino N	0.097	4.76
Mono-amino N	1.003	49.43

(2) *The Nitrogen Distribution in the Alkali-soluble Protein.*

The method used was the same as in the previous analysis. The nitrogen distribution was as follows:

	Dry matter %	Total nitrogen %
Total N	10.020	100.00
Hot 20% HCl soluble N	5.981	59.69
Hot 20% HCl insoluble N	4.039	40.31
Humin N	0.555	5.54
Amide N	1.162	11.60
Phosphotungstate N	2.373	23.68
Cystine N	0.188	1.88
Arginine N	0.703	7.02
Histidine N	0.944	9.42
Lysine N	0.537	5.36
Amino N	1.794	17.90
Non-amino N	0.579	5.78
Mono-amino	5.316	53.05

(3) *The Nitrogen Distribution in the Alcohol-soluble Protein.*

	Dry matter %	Total nitrogen %
Total N	13.120	100.00
Hot 20% HCl soluble N	12.372	94.30
Hot 20% HCl insoluble N	0.748	5.70
Humin N	1.452	11.07
Amide N	2.354	17.94
Phosphotungstate N	1.846	17.12
Cystine N	0.218	1.66
Arginine N	0.664	5.06
Histidine N	0.749	5.71
Lysine N	0.615	4.69
Amino N	1.249	9.52
Non-amino N	0.997	7.60
Mono-amino N	6.879	52.43

It is seen that Italian millet protein is rich in hexone base nitrogen and contains an adequate quantity of lysine nitrogen; it appears therefore to be of great nutritive value.

Feeding Experiments to determine the Nutritive Value of this Protein.

(1) *Preparation of the Ration.*

Millet flour was the sole source of protein in the ration and the other necessary components were added to it. The diet contained starch, butter (which was the source of vitamin A), Nelson's salt-mixture and, as a source of vitamin B, a small quantity of " oryzanine powder ". The proportions of the constituents of this ration were as follows:

Protein	10
Fat	14
Ash	4
Carbohydrate	72

The actual ration was made up as follows:

Italian millet powder	100 gr.
Butter	12 »
Nelson's salt-mixture	4 »
Starch	10 »

This mixture was heated with four times its weight of water on a water bath until dextrinised.

(2) *The Course of the Feeding Experiments.*

Five male and five female albino rats were given this diet from December 3rd, 1923, to August 7th, 1924.

This ration containing 10 per cent protein was sufficient to maintain normal growth in the rats, though there were some decreases of body weight during the period. The average initial body weight of the young male rats was 58 gr., and this increased to 306 gr.; the young female rats increased from an average initial weight of 59 gr. to 253 gr.

Notwithstanding the fact that this protein is of vegetable origin, it proves to be very favourable for growth.

17.

STUDIES ON THE PROTEIN OF BUCKWHEAT (*Jagopyrum esculentum moench.*) AND ITS NUTRITIVE VALUE.

By Minoru Hara

(From the Imperial State Institute for Nutrition, Tokyo).

Investigations concerning the chemical properties and nutritive value of buckwheat proteins have been carried out by various workers such as Ritthauser (1872), Yoshimura (1916), Johns and Chernoff (1918), Sawamura (1920), Kiesel (1922), and Matsuyama (1923).

By means of their varying solubilities in different solvents, buckwheat proteins can be separated into fractions. The nutritive value of that fraction of the protein separated by extraction with aqueous alkali has been examined by feeding it to young white rats. The experiments lasted from November 1922 to December 1924.

Experimental Procedure.

Samples of buckwheat flour were carefully prepared from the grain:

Sample No. I: produced in Naganoken in November 1922.
» No. II: produced in Kanagawaken in November 1923.
» No. III: flour from a market.

These three samples were analysed with the following results:

	Sample No. I %	Sample No. II. %	Sample No. III. %
H_2O	11.965	12.432	12.645
Dry matter	88.035	87.568	87.355
Cr. protein (N × 6.25)	13.606	13.337	14.250
Protein (N × 6.25)	10.250	10.019	9.381
Cr. fat	2.964	2.889	2.986
Cr. ash	2.276	2.278	2.623
N-free extract	80.161	80.515	78.934
Cr. fibre	1.003	0.981	1.207
Total N	2.177	2.134	2.280
Alb. N	1.640	1.603	1.549
Non-alb. N	0.537	0.531	0.731

Two methods were used to separate the proteins of buckwheat by means of their different solubilities: one was a fractional extraction method and the other an individual extraction method. The first method was as follows: 20 grams of the flour were extracted with 500 cc. of water and shaken for six hours at room temperature; after filtration, 300 cc. of water were added to the residue; the shaking and filtration were repeated and the two filtrates were mixed and made up to one litre. The nitrogen content of the combined filtrate was then estimated by Kjeldahl's method. A 10% saline solution was now added to the previous residue, which was extracted as before. Finally, extraction with 0.2% NaOH solution was carried out. The nitrogen content of the various fractions so obtained was as follows:

	Sample No. I %	Sample No. III %
Water-soluble N	30.75	40.63
10% NaCl soluble N	5.35	4.61
0.2% NaOH soluble N	45.40	40.27
N remaining in residue	18.50	14.48
Total N	100	100

The second method consisted in extracting separate samples with water, 10% saline solution, 0.2% alkali solution and 70% alcohol solution. During the alcohol extraction the temperature was kept constantly at 60° to 70° C.; filtration and estimation were carried out much as in the first method. The results of the nitrogen determinations were as follows:

	Sample No. I %	Sample No. II %	Sample No. III %
Water-soluble N	28.72	21.27	39.63
10% NaCl soluble N . . .	48.07	38.99	43.39
0.2% NaOH soluble N . .	81.89	78.81	61.53
70% alcohol soluble N . .	5.01	2.52	2.72
Total N	100	100	100

The above data show that an alkali solution can extract the main bulk of nitrogen from the flour, but an alcohol solution extracts only a small quantity.

Solutions extracted by all these solvents except alcohol give protein colour reactions, and have a more or less viscous character, this being particularly conspicuous in the case of the alkali solution, which could not be easily filtered clear.

The coagulable protein was separated from the filtrate resulting from the extraction with water by heating at 60° to 70° C. and adding dilute acetic acid. The protein yield thus obtained was as follows:

Sample No. 1.

Air-dried matter obtained from 100 grams original flour	3.35 grams
N yield for total N of flour	18.50% as dry matter
N content in the protein	13.95% » » »

The globulin obtained by extraction with saline solution was separated by the ordinary method of saturation with ammonium sulphate. The results were as follows:

Sample No. 1.

Air-dried matter obtained from 100 grams flour	1.85 grams
N yield for total N of flour	13.50% as dry matter
N content in globulin	15.50% » » »

The alkali-soluble protein solution was treated as follows: from the filtrate a protein substance was precipitated by adding acetic acid drop by drop until the solution became faintly acid. This precipitate was filtered and redissolved in alkali solution; after repetition of the precipitation and filtration, the precipitate was washed with water, alcohol and ether and then dried. This crude protein was dark brown; it probably consisted chiefly of glutelin and to a less extent of albumin and globulin; but, owing to the difficulties of purification of the individual simple proteins, it has not been decided how much of the last two was present.

The water, ash and nitrogen content of this substance were as follows:

	Sample No. I %	Sample No. II %	Sample No. III %
H_2O	10.72	4.98	11.50
N (dry matter)	14.874	15.820	13.481
Ash (dry matter)	0.74	0.84	1.08
P_2O_5 (dry matter)	0.36	—	—
Tryptophane (separated) . .	0.4	—	—
Air-dried matter obtained from 100 grams	8.57 gms.	9.79 gms.	8.19 gms.
N yield for total N of flour (dry matter)	60 %	70 %	49 %

The nitrogen distribution among several groups of amino acids was determined by Van Slyke's method as follows:

	Sample No. I		Sample No. II.	
	Dry matter %	Total N %	Dry matter %	Total N %
Total N	14.892	100.00	15.820	100.00
20% HCl sol. N.	14.352	96.37	14.958	94.55
20% HCl insol. N	0.526	3.53	0.843	5.33
Humin N	0.151	1.01	0.187	1.18
Amide N	1.679	11.28	1.167	7.38
Phosphotungstate N	4.586	30.80	4.654	29.42
Arginin N	2.247	15.09	2.228	14.08
Lysin N	0.732	4.92	0.830	5.26
Histidin N	1.416	9.51	1.371	8.67
Cystin N	0.191	1.12	0.225	1.42
Amino N	1.957	13.14	2.070	13.09
Non-amino N	2.629	17.66	2.586	16.33
Mono-amino N	7.936	53.29	8.950	56.58

Investigation of the nutritive value of the protein:

For these experiments alkali-soluble protein served as the source of protein on account of its comparatively large yield; casein was used as a control.

Animals: Albino rats 4 (♂) and 4 (♀).

Rations: Food mixtures as follows:

	Ration No. 1 %	Ration No. 3 %	Ration No. 2 %	Ration No. 4
Protein	20	15	10	
Butter	14	14	14	Same as No. 3 with the addition of buckwheat flour.
Starch	58	65	70	
Nelson's salt-mixture	6	4	4	
Agar	2	2	2	

Note. — Vitamins A, B and C were supplied from the butter, oryzanin and cabbage included in the ration.

Periods: From March 20th to December 14th, 1924.

The records of growth of the rats are shown in Figures 1 and 2.

Summary.

Buckwheat flour contains a large amount of aqueous alkali-soluble protein and a small amount of coagulable protein and globulin, but no alcohol-soluble protein. The solutions obtained by extraction with various solvents were all viscous except when alcohol was used as the solvent.

Aqueous alkali-soluble protein contains a large quantity of arginin and histidin. It appears to have a high nutritive value for rats, even higher than casein.

Figure 1 (♂).

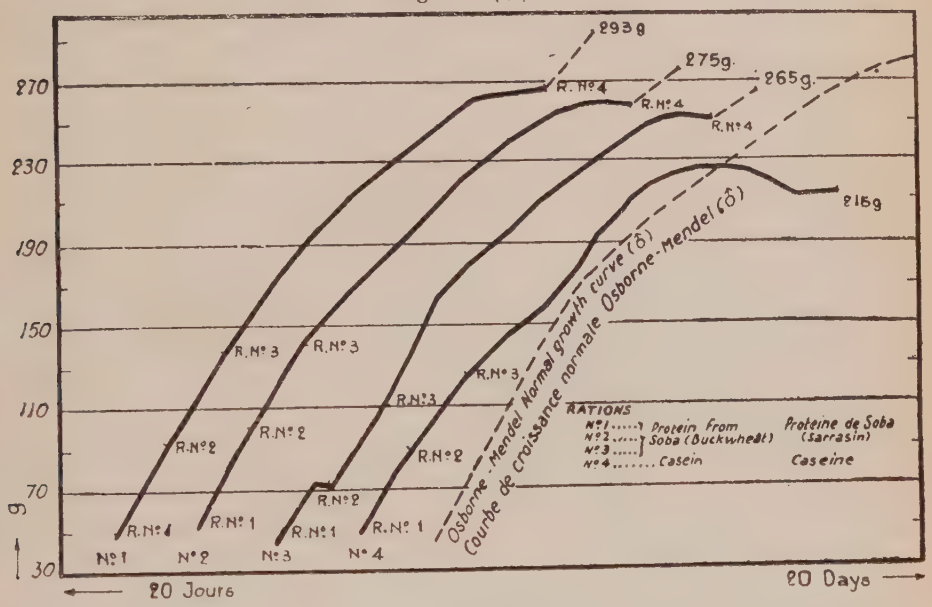
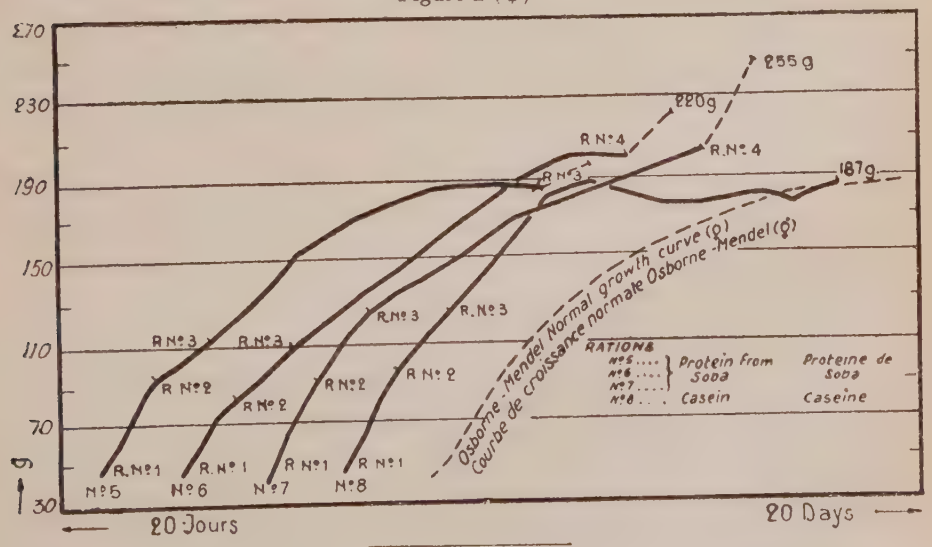


Figure 2 (♀).



18.

VITAMIN CONTENT OF JAPANESE FOOD MATERIALS.

By Y. Shimoda, Y. Fujimaki, H. Matsumuro and S. Saiki
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Purification of Food Materials.

Diet is the most important factor in vitamin work. If due attention is not paid to the purification of the foodstuffs and their mixing in correct proportions, the investigation will lose its value. The diet must contain all necessary nutritive elements except vitamins, must be adequate to supply the necessary calories, and must be digestible and palatable. By the term " perfect diet ", we mean a diet which contains an adequate amount of protein, carbohydrate, fat, mineral salts and vitamins. However, before we prepare a diet with these materials they must be purified. I have paid considerable attention to the purification, using the following procedures:

(a) *Casein used as a Source of Protein.*

Seven or eight pounds of casein were boiled for five or six hours with twice to three times its volume of 90 to 95 per cent alcohol on a water bath, using a reflex condenser to prevent the evaporation of alcohol. During the extraction the casein was stirred continuously to prevent burning by means of a stirring-rod driven by a motor. The mixture was filtered by a suction pump and the casein was well washed with alcohol. This procedure was repeated twice or three times and the casein was then dried and ground to a powder.

(b) *Dextrin used as a Source of Carbohydrate.*

Dextrin was treated exactly in the same way as the casein.

(c) *Olive Oil used as a Source of Fat.*

According to some authorities, olive oil does not contain vitamin A. I am not convinced of the truth of this statement; in my work it was used merely as a source of fat, but I heated the olive oil twice to 160 to 170° C. for several hours each time. During the heating, the oil was stirred continuously.

(*d*) I obtained bottom yeast from a brewing company and added a large amount of cold tap water, stirred well and then let it stand for several minutes; in this way the yeast was precipitated. The yeast was washed all night and then the hops were separated by passing the mixture through a silk sieve; the yeast was then compressed and dried by an air dryer and ground into a powder.

Normal Diet (for rats).

	%
Dextrin	65
Casein	18
Olive oil	7
Cod-liver oil	3
Salt mixture	5
Dried bottom yeast	2

Daikon juice was given freely to supply vitamin C.

The salt mixture consisted of:

NaCl	6.5
$MgSO_4H_2O$	13.3
$NaHPO_4H_2O$	10.0
K_2HPO_4	30.0
Ca-lactate	37.0
Fe-citrate	3.0

A trace of KI.

[Daikon or Japanese garden radish: According to Taro Higuchi's analysis it consists of 95.23 per cent of H_2O, 0.74 per cent of protein, 0.21 per cent of fat, 0.55 per cent of fibre, 0.47 per cent of ash and 2.04 per cent of carbohydrate. The Japanese are very fond of it and eat it all the year round. We investigated its vitamin content and found no vitamin A or B, but an abundance of vitamin C. Two c.c. of the juice per day is sufficient to protect from scurvy a guinea-pig weighing 200 to 300 grams. This daikon juice was clarified by adding about 5 per cent of fuller's-earth and used as a source of vitamin C.]

Vitamin A Deficient Diet (for rats).

	%
Casein	18
Dextrin	65
Olive oil	10
Dried bottom yeast	2
Salt-mixture	5

Ad libitum, daikon juice and water.

Vitamin B Deficient Diet (for albino rats).

	%
Dextrin	65
Casein	20
Olive oil	7
Cod-liver oil	3
Salt-mixture	5

Besides these materials, we gave daikon juice.

Vitamin B Deficient Diet (for pigeons).

	%
Polished rice	81
Casein	12
Cod-liver oil	3
Salt-mixture	4

Vitamin C Deficient Diet (for guinea-pigs).

	%
Oats	54
Casein	25
Cane sugar	5
Cod-liver oil	3
Olive oil	7
Salt-mixture	4
Dried bottom yeast	2

I. VITAMIN B CONTENT OF RICE.

New and Old Rice of Different Grades of Polishing.

The authors set out to determine the vitamin B content of new and old unpolished rice, 50%-polished rice, 70%-polished rice and polished rice. Rice polished with and without the use of sand powder was examined in our experiments.

In testing for the antineuritic vitamin we used 50 young pigeons weighing 250 to 300 grams, and for the examination of the growth-promoting vitamin we used 65 young white rats weighing 30 to 50 grams. The following experiments were carried out.

Experiment I.

To determine the variation in the antineuritic vitamin content of new and old unpolished rice after the lapse of one year we took groups of pigeons and gave them a basal diet composed of:

	%
Polished rice (polished by adding sand powder)	80
Purified casein	12
Salt-mixture	5
Fat (cod-liver oil)	3

Salt mixture consisting of:

NaCl	6.5
$MgSO_4H_2O$	13.0
$NaHPO_4H_2O$	10.0
K_2HPO_4	30.0
Ca-lactate	37.0
Fe-citrate	3.0

A trace of KI.

In the first group of pigeons we introduced daily into the stomach 5 grams of the old rice. These pigeons were free from polyneuritis at the end of three months.

In the second group of pigeons we introduced daily into the stomach 3 grams of the old rice. Seventy-five per cent of the pigeons became polyneuritic in three months.

In the third group of pigeons we introduced daily into the stomach 1 gram of the old rice. All the pigeons became polyneuritic in one month.

In the fourth group we introduced daily into the stomach 5 grams of the new rice. These pigeons were free from polyneuritis and grew well for over three months.

In the fifth group we introduced daily into the stomach 3 grams of the new rice. These pigeons were free from polyneuritis for over three months, and the physical condition of the pigeons was just about the same as that of the pigeons of group I.

In the sixth group we introduced daily into the stomach 1 gram of the new rice. The pigeons became polyneuritic in about two months.

We conclude that the vitamin B content of unpolished rice which has been stored for one year is less than that of new rice. The ratio of the vitamin B contents is 3 to 5.

Experiment II.

In this experiment we determined the antineuritic vitamin content of rice polished in different grades, namely, 50%-polished, 70%-polished and well-polished; we also compared rice polished with and without sand powder. Groups of pigeons were fed on the basal diet already mentioned.

In the first group we introduced daily into the stomach 5 grams of 50%-polished rice polished without sand powder.

In the second group we introduced daily into the stomach 7 grams of 70%-polished rice polished without sand powder.

In the third group we introduced daily into the stomach 10 grams of well-polished rice polished without sand powder.

In the fourth group we introduced into the stomach 10 grams of well-polished rice polished with sand powder.

The fifth group was given only the basal diet.

The first three groups of pigeons fed on the basal diet, with the addition of 5 grams of 50%-polished rice, 7 grams of 70%-polished rice, and 10 grams of well-polished rice, remained well and free from polyneuritis for five months. However, the physical condition of the pigeons to which we gave 5 grams of 50%-polished rice was not as good as that of the pigeons to which we gave 7 grams of 70%-polished rice. The physical condition of the pigeons to which we gave 10 grams of polished rice was worse than that of the pigeons to which we gave 5 grams of 50%-polished rice.

From these results, we came to the following conclusion: if the antineuritic vitamin content of unpolished rice is represented as 100, then that of 50%-polished rice is 55, that of 70%-polished rice is 43, while that of polished rice is 25. Rice fully polished with sand powder contains no antineuritic vitamin.

Experiment III.

We investigated the growth-promoting vitamin content of new and old rice and rices of different grades of polishing. For these experiments we used young white rats weighing 30 to 50 grams.

Group I. — Young white rats were fed on a diet composed of:

15% of old unpolished rice,
17% of purified casein,
54% of purified dextrin,
4% of salt mixture,
7% of purified olive oil,
3% of cod-liver oil.

Group II. — Rats received:

15% of new unpolished rice,
17% of purified casein,
54% of purified dextrin,
4% of salt-mixture,
3% of cod-liver oil,
7% of purified olive oil.

The duration of the experiment was six months. The first group of white rats attained nearly normal growth, the second group quite normal growth.

Group III. — Young white rats were fed on diets containing 15 and 25 per cent of 50%-unpolished rice, besides purified casein, dextrin, olive oil, cod-liver oil and salt-mixture. In neither case was growth quite normal, but the rats receiving 25 per cent of rice grew far better than those receiving 15 per cent of rice.

Group IV. — Young white rats were fed on diets composed of 25 and 35 per cent of 70%-polished rice. In neither case did the rats grow normally, although those fed on the diet containing 35 per cent of rice grew better than those fed on the diet containing only 25 per cent of rice.

Group V. — White rats fed on diets composed of 35 and 45 per cent of polished rice did not grow normally. The rats fed with 45 per cent of rice grew better than those fed on the diet containing 35 per cent of rice.

From these results we can place the rices in the following order as regards their growth-promoting activity: first, unpolished rice, then 50%-polished rice, then 70%-polished rice, and lastly polished rice. If the growth-promoting vitamin content of unpolished rice is represented as 100, that of 50%-polished rice is 50, that of 70%-polished rice is 35, and that of polished rice is 20.

It will be remembered that if the antineuritic vitamin content of unpolished rice is represented as 100, that of 50%-polished rice is 55, that of 70%-polished rice is 43, that of well-polished rice is 25, while that of rice polished with sand powder is zero.

The vitamin B content is diminished by storage of the rice and also by polishing to different grades. The catalytic action of the enzyme oxidase is diminished by the same factors, according to the work of Dr. Higuchi. We compared the degrees of diminution of vitamin B and oxidase and found that they ran parallel.

II. VITAMIN B IN JAPANESE BUCKWHEAT FLOUR

(Fagopyrum esculentum moench).

It is commonly believed that buckwheat has a curative effect on beri-beri, but no one seems to have studied the vitamin B content of buckwheat. We have carried out three series of experiments on pigeons; in two series we used the prophylactic method and in the third the curative method.

The First Prophylactic Experiment.

Twenty young pigeons were divided into five groups of four each. The first group received a diet lacking vitamin B, the fifth group a normal diet, and the other three groups received diets lacking vitamin B to which were added 10, 25 and 50 per cent of buckwheat flour respectively. The results were as follows:

Group I. — One died on the 13th day without having any symptoms of lack of vitamin B. One developed symptoms due to a lack of vitamin B on the 17th day, another on the 20th day and another on the 22nd day.

Group II. — One developed symptoms on the 33rd day and the other three had not developed symptoms when the experiment was discontinued on account of the great earthquake on September 1st.

Groups III, IV and V. — One had developed symptoms when the experiment was discontinued for the reason given above.

The Second Prophylactic Experiment.

Sixteen young pigeons were divided into four groups of four each. Group I received a diet lacking vitamin B, and groups II, III and IV received the same diet with the addition of 10, 25 and 50 per cent buckwheat flour respectively. The results were as follows:

	Number of days before symptoms developed	Number of days until death
Group I	19	21
Group II	(Average of 3) 35	(Average of 3) 38
Group III	—	—
Group IV	—	—

None of the birds in groups III and IV had developed symptoms in 82 days and one of those in group II failed to develop them in the same time. Group IV continued their normal growth, but the growth of groups II and III was not quite satisfactory.

The Third Experiment (Therapeutic).

Eight young pigeons were fed with a diet lacking vitamin B and, when beri-beri symptoms developed, they were divided into four groups of two each. 1, 2, 3 and 5 grams of buckwheat flour respectively were given daily by the mouth to the birds of the four groups.

Group I. — With 1 gram there was some curative effect, but it was not sufficient to cure the paralysis and the birds died in two to four days.

Group II. — With 2 grams the paralysis was cured and the body weight increased, but the birds died in 10 to 11 days.

Group III. — With 3 grams the paralysis was cured in five to eight hours and the body weight increased, but the birds did not grow normally.

Group IV. — The paralysis was cured in four to eight hours and normal growth was resumed.

The foregoing three experiments indicate that buckwheat flour contains a considerable amount of vitamin B.

III. VITAMIN A IN BUCKWHEAT FLOUR.

Fifty young mice of 25 to 35 grams body weight were fed with a diet lacking vitamin A, and when beri-beri symptoms developed, three each of the mild, the medium, and severe cases were selected and fed with a diet containing 75 per cent buckwheat flour, 11 per cent casein, 5 per cent salts, 10 per cent fat, and 2 per cent yeast.

The results are as follows:

Mild	no effect	died in 23 to 27 days.
Medium	»	died in 15 to 18 days.
Severe	»	died in 5 to 8 days.

The above experiment indicates that buckwheat flour either contains very little or no vitamin A.

IV. VITAMIN B CONTENT OF RED BEANS.

(Phaseolus Mung L.)

(a) *Curative Experiment.*

Red beans have been widely used for the treatment of beri-beri by the laity and by physicians. It was interesting to find out their actual vitamin B content.

A number of young pigeons received a diet lacking vitamin B and, when symptoms due to the lack of vitamin B had developed, they were given a definite quantity of red beans (pulverised, sifted through an 80-mesh gauze and then mixed with water). With 0.5 gram of beans they were cured of the symptoms, but their body weight did not increase and they died in one to three days. With 2 grams they were cured of the symptoms, but their body weight did not increase and they died in six to thirty days. With 3 grams they were cured of the symptoms, but their growth was not normal.

(b) *Prophylactic Experiment.*

We divided a number of young pigeons into two groups, and to one group we gave a vitamin B deficient diet to which were added 2 grams of red beans daily, and to the second group a vitamin B deficient diet to which were added 5 grams daily.

The first group showed no symptoms of beri-beri in 107 days, but their body weight decreased by 20 to 57 grams. The second group were entirely free from beri-beri; their body weight increased and growth was normal.

V. VITAMIN B CONTENT OF BEAN CURD.

(a) *Therapeutic Experiment.*

It is a well-known fact that beans contain a considerable amount of vitamin B. But whether or not foods prepared from them, such as bean curd, contain vitamin B is not yet known. The authors studied this point by the therapeutic method.

Twelve young pigeons were given a diet lacking vitamin B for two to three weeks, and when symptoms due to a lack of vitamin B had developed they were given 5, 10 or 20 grams of bean curd.

Five pigeons fed with 5 grams were not cured and died in one to three days.

Five pigeons fed with 10 grams were not cured and died in seven days.

Two pigeons fed with 20 grams were not cured and died in two to four days.

The above tests show that bean curd does not contain vitamin B.

(b) *Prophylactic Experiment.*

Six young pigeons were divided into two groups, and to the first group was given a vitamin B deficient diet together with 10 grams of bean curd daily; to the second group was given a vitamin B deficient diet with 20 grams of bean curd daily.

Group I. — One of the pigeons showed symptoms of beri-beri on the 23rd day of the experiment and died the next day. The other pigeons showed symptoms of beriberi on the 82nd to the 110th day of the experiment and died in 89 to 116 days.

Group II. — One pigeon showed symptoms of beri-beri on the 24th day and died on the 26th day, another showed symptoms on the 110th day, and died on the 114th

day, while the third showed no symptoms of beri-beri and lost no weight during the experiment.

Fom the above results we concluded that bean curd contains a very small quantity of vitamin B.

VI. VITAMIN B CONTENT OF THE MILK OF BEAN CURD.

(a) *Therapeutic Experiment.*

It was interesting to discover in which part of the process of preparation of bean curd vitamin B was lost. The milk of bean curd was first studied. Twelve young pigeons were given a diet lacking vitamin B, and when symptoms due to the lack of vitamin B had developed, 5, 10, 15 and 20 cc. of the milk were given daily.

With 5 cc. of the milk they were not completely cured and died in three to six days.

With 10 cc. they were cured of cramps, but they died in one to five days.

With 15 cc. they were cured of the symptoms, but even so they died in 10 to 33 days.

With 20 cc. they were cured completely and lived until the end of the experiment.

Thus it appears that the milk of bean curd contains more vitamin B than bean curd itself and the symptoms of beri-beri in pigeons may be cured with 20 cc. of the milk.

(b) *Prophylactic Experiment.*

Six young pigeons were divided into two groups; to the first group was given a vitamin B deficient diet with 10 cc. of bean-curd milk a day and to the second group was given a vitamin B deficient diet with 20 cc. of the milk.

The first group did not show symptoms of beri-beri, but gradually lost weight and at the end of the fourth month their body weight had decreased by an average of 27.4 per cent. The second group also showed no symptoms of beri-beri, but lost in weight. At the end of the fourth month, their weight had decreased by an average of 14.5 per cent.

From the above results we conclude that bean-curd milk contains more vitamin B than does bean curd itself.

VII. VITAMIN A IN LAVER.

Twenty-five young white rats were divided into three groups and given the following diets:

Group I. — Ten white rats had 10 per cent of laver.
Group II. — Ten white rats had a normal diet.
Group III. — Five white rats had a vitamin A deficient diet.

The rats of groups I and II grew normally without xerophthalmia, while the rats of group III developed eye symptoms in 40 to 50 days, and did not grow normally.

We conclude that laver contains a larger amount of vitamin A.

VIII. VITAMIN B IN LAVER.

Fifteen young pigeons were divided into two groups.

Group I. — Ten pigeons had 10 per cent of laver.
Group II. — Five pigeons had a vitamin B deficient diet.

Group I showed normal growth, but group II did not grow well, developed paralysis of the legs and finally died.

Thus, laver contains vitamin B. These experiments show that laver contains a large amount of vitamin A and a medium amount of vitamin B.

IX. VITAMIN A IN LARD.

(a) *Japanese Lard.*

In the first series of experiments it was not determined definitely whether lard contained vitamin A. In the second series lard was given to white rats which had developed eye symptoms owing to lack of vitamin A; 5, 10, and 15 per cent of lard was added to their diets and its effect was noted.

Group I (fed with 5 per cent of lard) died within 9 to 21 days.
Group II (fed with 10 per cent of lard) died within 9 to 79 days.
Group III (fed with 15 per cent of lard) died within 11 to 109 days.
Group IV (no lard was given) died within 5 to 16 days.

Thus the lard on the market contains a very small amount of vitamin A. Even 15 per cent of it added to a diet lacking vitamin A was not sufficient to cure xerophthalmia.

(b) *Vitamin A in Japanese Pharmacopœial Lard and American Lard.*

To determine the vitamin A content of Japanese pharmacopœial and American lard we took three groups of white rats with eye symptoms due to the lack of vitamin A. In the case of the first two groups, 15 per cent of lard (group I, pharmacopœial lard; group II, American lard) was added to the diet, and, in the case of the third group, 15 per cent of olive oil was added, and their effects were noted.

Group I (15 per cent of pharmacopœial lard) died within 12 to 14 days.
Group II (15 per cent of American lard) died within 11 to 15 days.
Group III (15 per cent of olive oil) died within 15 to 17 days.

From the above results we conclude that neither pharmacopœial nor American lard contains vitamin A.

X. VITAMIN A IN JAPANESE GARDEN RADISH.

Thirty young albino rats weighing about 30 grams were divided into three groups and fed as follows:

Group I was fed on a vitamin A deficient diet together with 15 per cent of garden radish.

Group II was fed on a vitamin A deficient diet without additions.
Group III was fed on a normal diet.

The results were as follows:

		Onset of xerophthalmia	Death
Group I	(Average)	57.5 days	71.6 days.
Group II	»	52 »	81 »
Group III	growth normal.		

Japanese garden radish does not contain vitamin A.

XI. VITAMIN B IN JAPANESE GARDEN RADISH.

Six young pigeons were given a vitamin B deficient diet containing 15 per cent of garden radish. The pigeons showed symptoms of beri-beri in 16 to 22 days and died in 20 to 30 days. We compared this result with that obtained by giving pigeons a vitamin B deficient diet without radish and found no difference between the two.

XII. VITAMIN C IN JAPANESE GARDEN RADISH.

It an earlier experiment it was found that garden radish contained a comparatively large amount of vitamin C; we therefore tested it quantitatively. A number of young guinea-pigs were divided into groups and treated as follows:

Group I was given 5 cc. of juice of radish by mouth daily.
Group II was given 2 cc. „ „ „ „
Group III was given 1 cc. „ „ „ „
Group IV received no radish juice.

The results were as follows:

Group I. — Sufficient growth.
Group II. — Very little growth.
Groups III and IV. — No growth, died with scurvy in an average of 32 days.

Thus the juice of garden radish contains a large amount of vitamin C. The minimum requirement of young guinea-pigs weighing from 200 to 300 grams is 2 cc. a day.

Vitamin C in Different Portions of the Garden Radish.

It is interesting to find out which portion of the radish contains most vitamin C. Fifteen guinea-pigs were divided into three groups of five each.

Group I had a vitamin C deficient diet.

Group II had 2 grams of radish peelings besides a vitamin C deficient diet.

Group III had 2 grams of the edible part of the radish besides a vitamin C deficient diet.

The results were as follows:

	Symptoms of scurvy	Death
Group I	(Average) 16 days	(Average) 28 days
Group II	No symptoms; continued to grow normally.	
Group III	(Average) 33 days	(Average) 50 days.

Thus vitamin C is present mainly in the peelings of garden radish.

XIII. VITAMIN A IN THE LEAVES OF THE JAPANESE GARDEN RADISH.

Ten young white rats with vitamin A deficiency symptoms were fed with various amounts of the green leaves of the garden radish and were watched to note the effect of the change of diet.

One rat which had marked eye symptoms due to a lack of vitamin A was fed with 5 grams of the leaves. It improved gradually and showed an increase of body weight.

Three rats which had ceased growth were fed with 3 grams of the leaves; they began to grow and improved generally.

Three rats which had quite well-marked eye symptoms were cured after receiving 2 grams of the leaves; their body weight gradually increased.

Three rats with eye symptoms were fed with 1 gram of the leaves. They all gradually improved and resumed normal growth; their xerophthalmia was cured within a week.

Thus the leaves of the garden radish contain a considerable amount of vitamin A.

XIV. VITAMIN C IN PICKLED VEGETABLES.

(a) *Vitamin C in Japanese Garden Radish Pickled in Salt, and in Rice-polishing Paste.*

No report has ever appeared on the food value of various pickles which have a special place in Japanese foods. The present investigation was undertaken to determine the vitamin C content of these pickles.

Fifteen young guinea-pigs were divided into three groups of five each.

Group I received a vitamin C deficient diet; group II received a vitamin C deficient diet together with 3 grams of radish pickled in rice-paste; group III received a vitamin C deficient diet together with 3 grams of radish pickled in salt.

The results were as follows:

	Symptoms of scurvy		Death	
Group I	(Average)	16 days	(Average)	28 days
Group II	»	16 »	»	35 »
Group III	»	24 »	»	46 »

When radish is pickled in paste its vitamin C is almost entirely lost; when pickled in salt its vitamin C is greatly decreased. The reason why vitamin C is decreased in pickled radish is that there has been a change in osmotic pressure, so that the vitamin is removed by osmosis; there is also some destructive action of an organic acid in the paste. The fact that microscopically the cells of the radish pickled in paste are markedly shrunken and that vitamin is found in the peelings indicates that the loss is due to osmotic action.

(b) *Vitamin C in Salt-pickled Hakusai.*

Four guinea-pigs were given a vitamin C deficient diet with 5 grams of salt pickled "hakusai"[1]. The animals continued to grow normally. When 5 grams

1 "Hakusai" is Chinese cabbage.

of salt-pickled " hakusai " were given to animals which already had symptoms of vitamin C insufficiency, the symptoms improved and they started to grow normally. These experiments show that salt-pickled " hakusai " contains a fairly large amount of vitamin C.

The foregoing experiments indicate that the decrease of vitamin C in vegetables pickled in yeast and rice bran is due not only to changes in osmotic pressure, but also to some organic acid in the salt rice-polishing mixture. The destructive action of organic acids and the loss due to osmotic pressure are being further investigated.

(c) *Vitamin C in Cabbage, Egg Plant and Cucumbers pickled in a Salt Rice-polishing Mixture.*

Twenty guinea-pigs were divided into four groups of five each.

Group I received a vitamin C deficient diet.
Group II received cucumbers pickled in a salt rice-polishing mixture.
Group III received egg plant pickled in the same mixture.
Group IV received cabbage pickled in the same mixture.

Only two or three animals survived throughout the experiment on account of the rainy season, so the results were not satisfactory. The experiment is being repeated and the results thus far obtained are as follows:

1. Salt rice-polishing pickled cucumbers contain a small amount of vitamin C.
2. Salt rice-polishing pickled egg plant contains a slight amount of vitamin C.
3. Salt rice-polishing pickled cabbage contains only a trace of vitamin C.

XV. VITAMIN A IN JAPANESE SOUR PICKLED PLUMS.

We took two groups of white rats with symptoms of xerophthalmia due to lack of vitamin A. In the case of the first group, 10 per cent of sour pickled plums was added to a diet which lacked vitamin A, and to the second group a vitamin A deficient diet alone was given. We found that there was no noticeable difference between the first and second groups; therefore, vitamin A is not present in pickled plums.

XVI. VITAMIN B IN JAPANESE SOUR PICKLED PLUMS.

Twelve young pigeons were divided into two groups; the first group was fed daily on a vitamin B deficient diet together with 5 grams of sour pickled plums, the second group was fed on a vitamin B deficient diet only.

The results were as follows:

	Onset of beri-beri		Death	
Group I	(Average)	18 days	(Average)	26 days
Group II	»	25 »	»	29 »

Thus sour pickled plums do not contain vitamin B.

XVII. VITAMIN C IN JAPANESE SOUR PICKLED PLUMS.

Experiment I.

Ten young guinea-pigs weighing about 200 grams were divided into two groups; group I was given a vitamin C deficient diet with 0.5 gram of neutralised sour plums and group II was given a vitamin C deficient diet alone.

The results were as follows:

	Onset of scurvy	Death
Group I	(Average) 24 days	(Average) 27 days
Group II	» 24 »	» 27 »

We may conclude that sour pickled plums have no appreciable vitamin C content.

Experiment II.

Twelve young guinea-pigs weighing about 200 grams were divided into three groups and were fed as follows:

Group I. — Vitamin C deficient diet with neutralised plum juice, 1 gram daily.

Group II. — Vitamin C deficient diet with neutralised plum juice, 1 cc. daily.

Group III. — Vitamin C deficient diet alone.

The results were as follows:

	Onset of scurvy	Death
Group I	(Average) 16 days	(Average) 25 days.
Group II	» 12 »	» 22 »
Group III	» 17 »	» 23 »

We may conclude that pickled plums do not contain much vitamin C.

XVIII. VITAMIN A IN JAPANESE SUMMER ORANGE.

Thirty young albino rats weighing from 41 to 53 grams were divided into three groups. Group I was supplied with vitamin A in the form of butter. Group II was given a diet lacking in vitamin A. Group III was given a diet lacking in vitamin A together with 20 per cent of the juice of summer orange.

Group I. — No symptoms of xerophthalmia even after 112 days, and growth was normal.

Group II. — Symptoms of xerophthalmia appeared in an average of 46 days and death occurred in an average of 65 days.

Group III. — Symptoms of xerophthalmia appeared in an average of 53.5 days and death occurred in an average of 79 days.

After eye symptoms had developed in one of the rats of group II, summer orange juice was given (33 per cent of the diet). There was a tendency to healing of the symptoms and an increase in body growth.

There seems to be some vitamin A in the juice of the summer orange.

XIX. VITAMIN B IN TAPES PHILIPPINARUM (FRESH-WATER SHELL-FISH, ASARI).

Ten young pigeons were divided into two groups and given a vitamin B deficient diet. Group I received 4 cc. of an alcoholic extract of the shell-fish (equal to 6 grams

of fresh asari) by mouth every day. Group II received the vitamin B deficient diet alone.

Group I developed symptoms of insufficiency in an average of 24.5 days and died in 26 days.

Group II developed symptoms of insufficiency in an average of 26.5 days and died in 27.5 days.

The shell extract had no effect; we conclude that *Tapes philippinarum* (asari) contains no vitamin B.

XX. VITAMIN A IN OYSTERS.

In the previous experiment we reported the vitamin B content of the fresh-water shell-fish shijimi or asari. The present report is concerned with the amount of vitamin A in the oyster. Twenty white rats with symptoms due to lack of vitamin A were divided into five groups of four each. The results were as follows:

Group I. — Vitamin A deficient diet with 1 gram of oyster a day; cured in 18 to 37 days, average 28 days.

Group II. — Vitamin A deficient diet with 2 grams of oyster a day; cured in 19 to 33 days, average 27 days.

Group III. — Vitamin A deficient diet with 3 grams of oyster a day; cured in 10 to 27 days, average 16 days.

Group IV. — Vitamin C deficient diet with 4 grams of oyster a day; cured in 7 to 20 days, average 10 days.

The oyster contains a considerable amount of vitamin A.

XXI. VITAMIN A CONTENT OF CANNED MEATS.

Since the great earthquake occurred in September 1922, the consumption of canned foods has increased greatly. We have therefore studied the vitamin A content of the following canned meats: corned beef, salmon and crab.

(a) *Vitamin A Content of Corned Beef.*

Fifteen young albino rats weighing about 25 grams were divided into three groups.

Group I was fed on a vitamin A deficient diet.

Group II was fed on a vitamin A deficient diet with 1 gram of corned beef daily.

Group III was fed on a vitamin A deficient diet with 3 grams of corned beef daily.

The results were as follows:

Group I. — The growth of the rats was poor; symptoms of xerophthalmia appeared in an average of 39.5 days and death occurred in an average of 53 days.

Group II. — One of the rats showed symptoms of xerophthalmia but was cured spontaneously, the other four rats did not develop xerophthalmia and their growth was normal.

Group III. — Two rats showed symptoms of xerophthalmia after 50 days but were cured spontaneously; their growth was normal. The other rats also grew normally.

Therapeutic Experiment.

Twenty young white rats were divided into four groups. These rats all had symptoms of xerophthalmia due to lack of vitamin A. To the first group a vitamin A deficient diet was given; to the second group was given a vitamin A deficient diet together with 3 grams of corned beef a day; to the third group was given a vitamin A deficient diet with 5 grams of corned beef a day; to the fourth group was given a vitamin A deficient diet with 10 grams of corned beef a day.

The first group died in from 7 to 15 days, while the other three groups were cured of xerophthalmia and grew normally.

Thus, corned beef contains some vitamin A.

(b) *Vitamin A Content of Canned Crab.*

Fifteen young white rats with symptoms of xerophthalmia due to lack of vitamin A were divided into four groups.

Group I was given a vitamin A deficient diet alone.

Group II was given a vitamin A deficient diet with 3 grams of canned crab daily.

Group III was given a vitamin A deficient diet with 5 grams of canned crab daily.

Group IV was given a vitamin A deficient diet with 10 grams of canned crab daily.

The results were as follows:

None of the animals in any of the four groups were cured of xerophthalmia. They all died and there was no difference in the duration of life between group I and the other three groups. Therefore, there was no recognisable vitamin A in canned crab.

(c) *Vitamin A Content of Canned Salmon.*

Fifteen white rats weighing about 25 grams were divided into three groups. To group I was given a vitamin A deficient diet alone, to group II was given a vitamin A deficient diet with 3 grams of canned salmon daily, to group III was given a vitamin A deficient diet with 5 grams of salmon daily.

The results were as follows:

Group I. — The rats showed symptoms of xerophthalmia in from 30 to 42 days, and died in 40 to 52 days.

Group II. — One of the rats showed symptoms of xerophthalmia on the 46th day and died on the 56th day of the experiment; the other four rats grew normally.

Group III. — All grew normally.

Therapeutic Experiment.

We took two groups of white rats with symptoms of xerophthalmia due to lack of vitamin A. To the first we gave a vitamin A deficient diet with 3 grams of salmon a day, and to the second group we gave a vitamin A deficient diet with 5 grams of salmon a day.

In the first group the symptoms were not cured and all died, but in the second group the symptoms were cured and all grew normally.

From these results we conclude that canned salmon contains some vitamin A.

XXII. VITAMIN A IN DRIED HERRING.

Eighteen young white rats were divided into three groups and were given the following diets:

To the first group was given a vitamin A deficient diet alone, to the second group a vitamin A deficient diet with 1 gram of dried herring daily, to the third group a vitamin A deficient diet with 3 grams of dried herring daily.

Group I developed xerophthalmia in 37 to 67 days, and died in 45 to 88 days.

Group II developed xerophthalmia in 57 to 125 days, and died in 130 to 169 days.

Group III had not developed xerophthalmia in six months, and grew normally.

We concluded that dried herring contains a medium amount of vitamin A.

XXIII. VITAMIN A IN DRIED HERRING-ROE.

Twenty-five young white rats were divided into three groups, and were given the following diets:

To the first group was given a vitamin A deficient diet alone, to the second group a vitamin A deficient diet of which 10 per cent was dried herring-roe, to the third group a vitamin A deficient diet 20 per cent of which was dried herring-roe.

Group I developed xerophthalmia in 32 to 75 days, and died in 43 to 98 days.

Group II developed xerophthalmia in 83 to 118 days and died in 100 to 131 days.

Group III developed xerophthalmia in 100 to 139 days, and died in 118 to 170 days.

The rats receiving 20 per cent of dried herring-roe lived longest of all, next came those receiving 10 per cent dried herring-roe; those fed on a vitamin A deficient diet alone were the first to die.

From the above results we concluded that dried herring-roe contains some vitamin A.

XXIV. VITAMIN A IN EELS.

Eels are eaten in Japan a great deal; we therefore decided to investigate their vitamin A content.

Fifteen young white rats were divided into three groups, and were given the following diets:

Group I a vitamin A deficient diet alone.
Group II a vitamin A deficient diet with 0.5 grams of broiled eel.
Group III a vitamin A deficient diet with 1 gram of broiled eel.

The results were as follows:

Group I. — The rats developed xerophthalmia in 32 to 75 days and died in 50 to 90 days.

Group II. — Except in the case of one rat, growth was normal and there was freedom from xerophthalmia.

Group III. — Normal growth.

A number of young rats were given a diet lacking vitamin A and when symptoms due to lack of vitamin A had developed 0.2 grams, 0.5 grams, 1 gram and 3 grams of eel were added.

With 0.2 grams they were not cured of the symptoms and soon died.

With 0.5 grams, 1 gram and 3 grams they were cured of the symptoms completely and resumed normal growth.

From the above results we conclude that eel contains a considerable amount of vitamin A.

XXV. VITAMIN A IN LAMPREY.

(Entosphemis japonicus.)

Experiment I.

River lamprey has been used for a long time by the laity for the cure of hemeralopia. It is interesting to determine whether or not this kind of eel contains vitamin A.

Six white rats with symptoms due to lack of vitamin A were divided into two groups of three each and fed with 1 gram and 0.5 gram of the lamprey in addition to the diet lacking vitamin A.

The results were as follows:

Group I. — Cured in 3 to 6 days and resumed growth.
Group II. — „ „ 9 to 15 „ „ „ „

This indicates that the lamprey *(Entosphemis j.)* contains a large amount of vitamin A.

Experiment II.

Next ten young white rats were given a diet lacking vitamin A and, when symptoms due to lack of vitamin A had developed, 0.1 and 0.2 gram of dried lamprey were added to the diet.

With 0.1 gram as well as with 0.2 gram they were cured of the symptoms completely and resumed normal growth.

Thus in young white rats less than 0.1 gram of dried lamprey daily supplies a sufficiency of vitamin A.

19.

EFFECT OF ALKALOIDS ON ANIMALS FED ON DIETS DEFICIENT IN VITAMINS.

By Sanetoshi Saiki

(From the Imperial State Institute for Nutrition, Tokyo).

I carried out the following experiments to compare the effect of alkaloids on animals fed on vitamin deficient diets with their effect on animals fed on a normal diet.

Experiment I.

Young albino rats weighing 25 to 50 grams were fed on a normal diet for five months. The food materials were well purified and mixed as in the accompanying tabulation:

	%
Dextrin	65
Casein	18
Olive oil	7
Cod-liver oil	3
Salt mixture	5
Dried bottom yeast	2

The salt mixture was made up as follows:

	%
NaCl	6.5
$MgSo_4H_2O$	13.0
$NaHPO_4H_2O$	10.0
$K_2PHO_4H_2O$	30.0
Ca-lactate	37.0
Fe-citrate	3.0

A trace of KI.

I selected 63 rats fed on the diet mentioned above, injected them hypodermically with a solution containing 0.5 gm. of strychnine nitrate in one litre of H_2O, and observed their resistance to the drug. The doses used for injection were 0.0005 gm.,

0.0004 gm., 0.00035 gm., 0.0003 gm., 0.00028 gm., 0.00025 gm., 0.0002 gm., 0.00017 gm., 0.00015 gm., and 0.0001 gm., per 100 gms. of body weight.

The following table gives a summary of the results:

	0.0005 gm.	0.0004 gm.	0.00035 gm.	0.003 gm.	0.00028 gm.
Number killed. . .	2	7	10	13	2
Number survived .	0	0	0	2	0
Death rate	100 %	100 %	100 %	87 %	100 %

	0.00025 gm.	0.0002 gm.	0.00017 gm.	0.00015 gm.	0.0001 gm,
Number killed. . .	3	4	4	3	0
Number survived .	0	3	2	2	6
Death rate	100 %	57 %	66 %	60 %	0 %

Experiment II.

Young but fairly - well - grown rats were fed on a diet deficient in vitamin A for 42 to 76 days.

The diet was composed of:

	%
Casein	18
Dextrin	65
Olive oil	10
Dried bottom yeast	2
Salt mixture	5

I selected 21 animals fed on the above-mentioned diet, and injected them with strychnine as before, observing their resistance to the drug. The doses used for injection were much the same as in the last experiment. The following results were obtained:

	0.0005 gm.	0.0004 gm.	0.00035 gm.	0.0003 gm.	0.00025 gm.
Number killed. . .	2	2	1	1	2
Number survived .	0	1	0	0	1
Death rate	100 %	66 %	100 %	100 %	66 %

	0.0002 gm.	0.0015 gm.	0.0001 gm.
Number killed. . .	2	1	0
Number survived .	3	3	2
Death rate	40 %	25 %	0 %

Experiment III.

A number of young albino rats were fed on a vitamin B deficient diet for 71 to 76 days; 23 of them were then injected with strychnine as before. The following

doses were used: 0.0003 gm., 0.00025 gm., 0.0002 gm., 0.00015 gm., and 0.0001 gm. per 100 grams of body weight. I obtained the following results:

	0.0003 gm.	0.00025 gm.	0.0002 gm.	0.0015 gm.	0.0001 gm.
Number killed . . .	3	2	2	1	0
Number survived .	1	2	3	5	4
Death rate	75%	50%	40%	16%	0%

Experiment IV.

(*a*) Young guinea-pigs were fed on a normal diet composed of:

	%
Oats	59
Casein	25
Salt-mixture	4
Olive oil	7
Cod-liver oil.	3
Dried bottom yeast	2

Daikon juice *ad libitum* as a source of vitamin C.

I selected 40 animals and injected them with the following amounts of strychnine per 100 grams of body weight: 0.0005 gm., 0.0004 gm., 0.00035 gm., 0.0003 gm., 0.00025 gm., and 0.0002 gm. I obtained the following results:

	0.0005 gm.	0.0004 gm.	0.00035 gm.	0.0003 gm.	0.00025 gm.	0.00002 gm.
Number killed	2	5	4	3	0	0
Number survived . . .	0	4	6	6	8	2
Death rate	100%	55%	40%	33%	0%	0%

(*b*) Fairly-well-grown guinea-pigs were fed on a vitamin C deficient diet for 28 to 53 days. Nineteen were selected for the following experiment.

The diet was composed of:

	%
Oats	59
Casein	25
Salt–mixture	4
Olive oil	7
Cod-liver oil	3
Dried bottom yeast	2

The following amounts of strychnine were injected hypodermically per 100 grams of body weight. I obtained the following results:

	0.0005 gm.	0.0004 gm.	0.00035 gm.	0.0005 gm.
Number killed . .	2	3	0	0
Number survived .	0	6	4	4
Death rate	100%	33%	0%	0%

These experiments are very delicate and easily influenced by the conditions; therefore I paid special attention to obtaining as nearly identical conditions as possible. Death was decided to have occurred when the corneal reflex had disappeared

When these experiments were performed, the intervals that elapsed from the time of injection of strychnine to the onset of cramp, from the time of injection of strychnine to death, and from the time of onset of cramp to death, were very carefully recorded. The fatal doses might require in the different groups different times to produce their effects, and further light might thus be thrown on the problem of increase or decrease of sensitiveness to strychnine.

These various times are shown in the following tables:

Rats fed on a Normal Diet.

Dose de strychnine par 100 gr. d'animal (gr.) Dose of strychnine per 100 gms. of body weight (gms.)	Nombre d'animaux Total number of animals	Nombre de morts Number of deaths	Mortalité (%) Death rate %	Temps moyen nécessaire à l'apparition de convulsions Average time required for cramp to appear	Temps moyen qui sépare l'injection de la mort Average time required from injection to death	Temps moyen entre les convulsions et la mort Average time required from cramp to death
0.0005	2	2	100	16′ 35″	20′ 58″	4′ 23″
0.0004	7	7	100	18′ 09″	21′ 09″	3′ 00″
0.00035	10	10	100	13′ 03″	18′ 16″	5′ 13″
0.0003	15	13	87	20′ 14″	26′ 00″	5′ 46″
0.00028	2	2	100	15′ 23″	17′ 13″	1′ 50″
0.00025	3	3	100	31′ 16″	37′ 06″	5′ 50″
0.0002	7	4	57	18′ 53″	26′ 28″	7′ 35″
0.00017	6	4	66	14′ 29″	19′ 30″	5′ 01″
0.00015	5	3	60	13′ 12″	16′ 58″	3′ 46″
0.0001	6	0	0	—	—	—

Rats fed on a Vitamin A Deficient Diet.

Dose de strychnine par 100 gr. d'animal (gr.) Dose of strychnine per 100 gms. of body weight (gms.)	Nombre d'animaux Total number of animals	Nombre de morts Number of deaths	Mortalité (%) Death rate %	Temps moyen nécessaire à l'apparition de convulsions Average time required for cramp to appear	Temps moyen qui sépare l'injection de la mort Average time required from injection to death	Temps moyen entre les convulsions et la mort Average time required from cramp to death
0.0005	2	2	100	7′ 40″	24′ 40″	7′ 00″
0.0004	3	2	66	9′ 20″	13′ 20″	4′ 00″
0.00035	1	1	100	—	—	—
0.0003	1	1	100	37′ 05″	38′ 55″	1′ 50″
0.00025	3	2	66	11′ 44″	12′ 48″	1′ 04″
0.0002	5	2	40	37′ 39″	56′ 42″	19′ 03″
0.00015	4	1	25	13′ 00″	14′ 30″	1′ 30″
0.0001	2	0	0	—	—	—

Rats fed on a Vitamin B Deficient Diet.

Dose de strychnine par 100 gr. d'animal (gr.) Dose of strychnine per 100 gms. of body weight (gms.)	Nombre d'animaux Total number of animals	Nombre de morts Number of deaths	Mortalité (%) Death rate %	Temps moyen nécessaire à l'apparition de convulsions Average time required for cramp to appear	Temps moyen qui sépare l'injection de la mort Average time required from injection to death	Temps moyen entre les convulsions et la mort Average time required from cramp to death
0.0003	4	3	75	15′ 33″	33′ 54″	18′ 21″
0.00025	4	2	50	11′ 50″	16′ 25″	4′ 35″
0.0002	5	2	40	14′ 55″	18′ 00″	3′ 05″
0.00015	6	1	16	12′ 00″	17′ 40″	5′ 40″
0.0001	4	0	0	—	—	—

Guinea-pigs fed on a Normal Diet.

Dose de strychnine par 100 gr. d'animal (gr.) Dose of strychnine per 100 gms. of body weight (gms.)	Nombre d'animaux Total number of animals	Nombre de morts Number of deaths	Mortalité (%) Death rate %	Temps moyen nécessaire à l'apparition de convulsions Average time required for cramp to appear	Temps moyen qui sépare l'injection de la mort Average time required from injection to death	Temps moyen entre les convulsions et la mort Average time required from cramp to death
0.0005	2	2	100	16′ 28″	32′ 50″	16′ 22″
0.0004	9	5	55	7′ 53″	15′ 58″	8′ 05″
0.00035	10	4	40	14′ 23″	45′ 23″	30′ 49″
0.0003	9	3	33	—	15′ 00″	—
0.00025	8	0	0	—	—	—
0.0002	2	0	0	—	—	—

Guinea-pigs fed on a Vitamin C Deficient Diet.

Dose de strychnine par 100 gr. d'animal (gr.) Dose of strychnine per 100 gms. of body weight (gms.)	Nombre d'animaux Total number of animals	Nombre de morts Number of deaths	Mortalité (%) Death rate %	Temps moyen nécessaire à l'apparition de convulsions Average time required for cramp to appear	Temps moyen qui sépare l'injection de la mort Average time required from injection to death	Temps moyen entre les convulsions et la mort Average time required from cramp to death
0.0005	2	2	100	6′ 22″	7′ 25″	1′ 03″
0.0004	9	3	33	4′ 40″	12′ 55″	8′ 15″
0.00035	4	0	0	—	—	—
0.0003	4	0	0	—	—	—

As shown in the tables, there is considerable individual variation in the times required for the symptoms to develop : these times bear no special relation to differences in the diets.

Summary :

1. The effect of injection of strychnine is different in the case of rats fed on a normal diet and those fed on a vitamin deficient diet.
2. Rats fed on a normal diet react to relatively small doses of strychnine.
3. Rats fed on a vitamin A deficient diet can stand larger doses of strychnine than those fed on a normal diet.
4. Rats fed on a vitamin B deficient diet can stand larger doses of strychnine than those fed on a normal diet, but not so large as rats fed on a vitamin A deficient diet.
5. Guinea-pigs fed on a vitamin C deficient diet can stand larger doses of strychnine than those fed on a normal diet.
6. Whether these differences are due to increase of resistance or decrease of sensitiveness cannot be decided without further investigation.

20.

RELATIONSHIP BETWEEN THE QUANTITY OF SALTS IN A DIET AND VITAMIN A DEFICIENCY.

By Fuichi Nakamura

(From the Imperial State Institute for Nutrition, Tokyo.)

The relationship between the quality of inorganic salts in a food mixture and vitamin A deficiency has been investigated by various workers, but I have not heard of any work concerned with the relationship between the total quantity of salt mixture in a diet and vitamin A deficiency. Therefore I performed the following experiments.

Experiment I.

Young albino rats were divided into three groups. To the first group was given a vitamin A deficient diet containing only 0.5 per cent of a salt mixture.

The diet was composed of:

	%
Purified casein	15
Polished-rice flour	75
Olive oil	10
Orizanin	0.6
Salt mixture	0.5

The salt mixture was composed of:

NaCl	6.5
$MgSO_4H_2O$	13.0
$NaHPO_4H_2O$	10.0
K_2HPO_4	30.0
Ca-lactate	37.0
Fe-citrate	3.0
KI	0.5

The second group of animals were fed on a vitamin A deficient diet containing 2 per cent of the salt mixture.

The diet was composed of:

	%
Purified casein	15
Polished-rice flour	75
Olive oil	10
Orizanin	0.6
Salt mixture	2

To the third group was given a vitamin A deficient diet containing 5 per cent of salt mixture.

The diet was composed of:

	%
Purified casein	15
Polished-rice flour	75
Olive oil	10
Orizanin	0.6
Salt mixture	5

The first group of rats grew well for the first two or three weeks, but after that they did not grow so well; some of them developed xerophthalmia, while others died without developing xerophthalmia. The second group of rats grew much better than the first group and lived longer. The third group of rats did far worse than the other two and died much sooner.

In short, to prolong the life of animals fed on a vitamin A deficient diet, the *optimum* amount of salt mixture should be added.

21.

FORMATION OF URINARY AND BILE-DUCT CALCULI IN ANIMALS FED ON EXPERIMENTAL RATIONS.

By Yoshitomo Fujimaki

(From the Imperial State Institute for Nutrition, Tokyo).

I.

Calculi have long afflicted the human race; Eliott Smith has found urinary calculi in mummies supposed to be 4,000 years old. Hippocrates (460-377 B.C.) was probably the first man who ever discussed the cause of the formation of calculi. Since his time numerous hypotheses have been advanced in regard to the formation of calculi, but none have proved satisfactory. Chworastansky found kidney stones in 88 per cent of 58 rachitic patients. Uyeda has found kidney stones in dogs kept on boiled polished rice and distilled water. Osborne and Mendel have found urinary calculi in rats fed on experimental rations.

Kirschner and Clemm observed that, in Germany, gall-stones were found more commonly in people who took diets containing only a small amount of fat. Moreover, Padua claims a definite relationship between beri-beri and calculi.

During the early years of investigation of the vitamin content of Japanese food materials, under the supervision of Dr. Saiki, I recognised a number of urinary and bile-duct calculi among rats kept for a long period on vitamin A poor or free diets. I thought that there must be a certain relationship between the formation of concretions and dietetic factors, especially vitamins and mineral salts; in pursuance of this idea I tried to determine whether vitamin A, vitamin B, vitamin C, vitamin A and C, or vitamin B and C, or some other factor such as mineral salts, especially calcium and phosphorus, or protein deficiency combined with the vitamin A poor or free diet, were the cause of the formation of concretions. I carried out the following experiments.

Purification of Food Materials.

The experimental diets used in vitamin work must contain the necessary nutritive elements and must be adequate to supply the necessary calories; they must also be digestible and palatable. By the term " perfect diet ", we mean a diet which contains an adequate amount of protein, carbohydrate, fat, mineral salts and vitamins. However, before we make up a diet with these materials they must be purified. I have paid considerable attention to the purification, using the following methods:

(a) *Casein used as a source of protein.*

Seven or eight pounds of casein were boiled for five or six hours with two to three times its volume of 90 to 95% alcohol on a water bath, using a reflex condenser to prevent the evaporation of alcohol. During the extraction the casein was stirred continuously by a motor. The mixture was filtered with a suction pump and the casein was then well washed with alcohol. This procedure was repeated twice or three times and the casein was then dried and ground to a powder.

(b) *Dextrin used as a source of carbohydrate.*

Dextrin was treated exactly in the same way as casein and made into a powder.

(c) *Olive oil used as a source of fat.*

According to some authorities, olive oil does not contain vitamin A; I am not convinced of the truth of this statement. However, in my work it was used merely as a source of fat, but I heated the olive oil twice to 160°-170° C. for several hours each time. During the heating, the oil was stirred constantly.

(*d*) I obtained bottom yeast from a brewing company and added to it a large amount of cold tap water; after stirring well it was allowed to stand for several minutes till the yeast was precipitated. The yeast was then washed all night, and the hops were removed by means of a silk sieve; the yeast was compressed and dried by an air dryer and ground into a powder.

Experiment 1. — Animals fed on a Vitamin A Deficient Diet.

(*a*) One hundred and seven albino rats were fed on a vitamin A deficient diet. The majority of the rats weighed 25 to 30 grams at the beginning of the experiment, although some of them were well grown and weighed 200 to 300 grams or even more. Young rats fed on the vitamin A free diet did not survive long, so I occasionally fed them with a normal diet to keep them alive. The food materials were well purified and mixed as in the accompanying tabulation:

	%
Casein	18
Dextrin	65
Olive oil	10
Dried bottom yeast	2
Salt mixture	5

Daikon juice to supply vitamin C and water *ad libitum*.

The salt mixture consisted of:

	%
NaCl	6.5
$MgSO_4H_2O$	13.0
$NaHPO_4H_2O$	10.0
K_2HPO_4	30.0
Ca-lactate	37.0
Fe-citrate	3.0

A trace of KI.

Forty-one of the 107 rats were kept on this diet for periods of from two to 30 days, but no calculi were found; 13 rats were kept for 41 to 50 days and three

of them (23 per cent) had bladder stones, but none had kidney or bile-duct stones; 36 rats were kept for 51 to 80 days and six cases (37 per cent) of bladder stones and one case (6 per cent) of kindney stones were found, but no bile-duct stones; six rats were kept for 81 to 100 days and five cases (83 per cent) of bladder stones and two cases (33 per cent) of kidney stones were found, but no bile-duct stones; eight rats were kept for 120 to 140 days and eight cases (100 per cent) of bladder stones, six cases (75 per cent) of kidney stones and one case (12 per cent) of bile-duct stones were found; eight rats were kept for 150 to 210 days and in seven cases (85 per cent) there were bladder stones, in six cases (75 per cent) kidney stones and five cases (63 per cent) bile-duct stones; six rats were kept for 245 to 376 days and all six had bladder stones (100 per cent), five (83 per cent) had both kidney and bile-duct stones.

These experimental data are shown in the following table (rats kept less than 30 days are not included):

N° de l'animal No. of animal	Sexe Sex	Poids — Body weight		Apparition de la xérophtalmie Symptom of xerophthalmia appears	Durée du régime Duration of feeding	Calculs — Calculi		
		Début de l'expér. Beginning of experiment	Fin de l'expér. End of experiment			Vessie Bladder	Rein Kidney	Voies biliaires Bile duct
		gr.-gms.	gr.-gms.	Jours-Days	Jours-Days			
207	♀	22	48	32	39	—	—	—
208	♀	20	37	—	32	—	—	—
216	♀	37	105	—	31	—	—	—
217	♂	32	99	—	32	—	—	—
223	♂	25	80	—	31	—	—	—
168	♀	32	58	27	35	+	—	—
182	♂	31	47	—	36	—	—	—
184	♀	29	50	—	32	—	—	—
751	♀	27	23	—	40	—	—	—
120	♂	31	90	—	49	—	—	—
126	♀	40	71	43	49	—	—	—
32	♀	52	12	11	49	+	—	—
133	♂	54	159	21	49	—	—	—
138	♂	43	115	11	48	—	—	—
139	♂	50	180	—	49	—	—	—
141	♂	47	129	21	50	—	—	—
142	♂	32	53	14	42	—	—	—
150	♀	35	55	35	42	—	—	—
151	♀	45	114	34	41	—	—	—
179	♂	20	61	39	43	—	—	—
204	♂	32	65	32	50	+	—	—
241	♀	47	105	36	48	++	—	—
125	♀	35	82	42	56	—	—	—
128	♂	34	72	35	53	+	—	—
219	♂	25	116	—	60	—	—	—
224	♂	25	70	38	59	—	—	—
227	♀	25	82	36	58	—	—	—

N° de l'animal No. of animal	Sexe Sex	Poids — Body weight		Apparition de la xérophtalmie Symptom of xerophthalmia appears	Durée du régime Duration of feeding	Calculs — Calculi		
		Début de l'expér. Beginning of experiment	Fin de l'expér. End of experiment			Vessie Bladder	Rein Kidney	Voies biliaires Bile duct
		gr.-gms.	gr.-gms.	Jours-Days	Jours-Days			
228	♀	25	76	38	55	+	—	—
2	♀♀	46	65	40	56	—	—	—
221	♂♀	32	108	—	62	+	—	—
234	♀♀	31	130	39	62	+	+	—
242	♀♀	46	54	41	63	+	—	—
51	♀♀	25	82	—	75	+	—	—
243	♀♀	50	145	28	70	—	+	—
4	♂♀	61	91	48	73	—	—	—
3	♀♀	44	89	—	77	—	—	—
8	♂♀	37	113	26	76	+	—	—
7	♂♂	42	85	35	66	—	—	—
238	♂♂	44	128	—	87	+	—	—
239	♂♀	41	86	31	81	+++	++	—
240	♂♂	39	113	65	81	+	—	—
225	♂♀	23	80	41	88	+	—	—
232	♀♀	32	120	35	94	+	+	—
6	♀♀	51	93	64	88	—	—	—
9	♂♂	56	181	35	127	++	+	—
236	♂♂	35	213	50	121	+	+	—
244	♂♀	32	146	39	122	+++	—	—
250	♂♀	37	85	81	122	++++	+++	—
5	♂♀	51	165	24	127	++	+	—
273	♀♀	20	114	75	138	+++	++	+
275	♀♀	27	170	93	128	++	++	—
252	♀♀	40	116	30	136	+++	—	—
266	♂♂	54	280	21	157	++++	+++	+
272	♂♂	24	237	32	157	—	—	+++
300	♂♂	43	280	—	151	+++	++	—
10	♀♀	53	127	45	197	+++	+++	+
277	♂♀	34	257	—	207	++	++	—
278	♀♀	42	87	35	207	+++	+	+
279	♀♀	38	95	20	207	+++	++	++
280	♂♀	286	213	—	209	+	—	—
260	♀♀	43	153	50	376	++++	+++	++++
371	♂♂	31	183	31	271	+++	++	+
301	♂♂	365	230	—	260	++++	+++	++++
393	♀♀	228	180	136	235	++++	+++	++
788	♂♂	285	209	201	242	+++	—	—
799	♂	296	213	—	245	++	—	—

According to the above results, animals fed on a vitamin A deficient diet for a long period develop calculi; bladder stones are formed in a relatively short period, kidney stones later and bile-duct stones last of all.

(*b*) Thirty young so-called Chinese mice weighing 8 to 14 grams were fed on the vitamin A deficient diet for from two to 295 days. The majority of them showed symptoms of xerophthalmia within 25 days and most of them died a few days later. In order to maintain life, I gave the survivors occasionally a vitamin A rich diet, and proceeded with the experiment.

Twenty-one out of 30 mice died within 31 days, none having calculi; four mice were kept 58 to 65 days and two cases (50 %) of bladder stone were found, but there were no other stones; three mice were kept 112 to 121 days and all had bladder stones (100 %), one had kidney stones (33 %), but there were no bile-duct stones; one mouse lived for 295 days, and it was found to have bladder, kidney and bile-duct stones.

The results are shown in the following table (21 rats died within 31 days, and are not included in the table):

N° de l'animal No. of animal	Sexe Sex	Poids Body weight		Apparition de la xérophtalmie Symptom of xerophthalmia appears	Durée du régime Duration of feeding	Calculs — Calculi		
		Début de l'expérience Beginning of experiment	Fin de l'expérience End of experiment			Vessie Bladder	Rein Kidney	Voies biliaires Bile duct
		gr. — gms.	gr. — gms.	Jours — Days	Jours — Days			
30	♀	11	10	—	32	—	—	—
1	♂♀	10	12	25	58	+	—	—
9	♂♀	10	11	—	59	—	—	—
12	♂♀	8	9	20	62	+	—	—
13	♂♀	10	9	12	65	—	—	—
29	♀	10	8	—	112	+	—	—
22	♂	10	13	25	116	++	+	—
25	♂	12	12	18	121	+	—	—
7	♂	7	21	280	295	++++	+++	++++

In the case of Chinese mice also, the concretions are not found among animals kept only for a short period, but are found among animals kept for a long period. In these animals, too, bladder stones were the earliest to form, then kidney stones, bile-duct stones taking the longest time.

(*c*) Five puppies of the same litter, about 40 days old and weighing 1,200 to 1,720 grams, and also an 18-months-old dog weighing 10,511 grams, were fed on a vitamin A free diet for from nine to 101 days. The diet consisted of:

	%
Polished rice (dry)	71
Casein	12
Olive oil	10
Salt mixture	5
Dried bottom yeast	2
Daikon juice	30 to 50 c.c. per day.

The dried polished rice was cooked and casein, olive oil, salt mixture, dried yeast and daikon juice were added to it.

Five of the dogs were either dead or were killed within 71 days, but none of them had any calculi, although one of the dogs showed symptoms of xerophthalmia within 40 days. One puppy lived for 101 days and was found to have both bladder and kidney stones.

Experiment II. — Rats fed on Vitamin A and C Deficient Diet.

One hundred and seventy-eight albino rats weighing 30 to 40 grams (five of them were well grown) were fed on a vitamin A and C deficient diet for three to 238 days. The diet was composed of:

	%
Dextrin	65
Casein	18
Olive oil	10
Salt mixture	5
Dried bottom yeast	2

Seventy-nine out of 178 rats were dead within 30 days, but had no calculi; among 16 rats kept for 31 to 40 days there were two cases (12 per cent) of bladder stones only; among 30 rats kept for 41 to 50 days five (17 per cent) with bladder stones were found, but no other stones; 27 rats were kept for 51 to 80 days and nine (33 per cent) had bladder stones and two (7 per cent) had kidney stones, but there were no bile-duct stones; eight rats were fed for 71 to 100 days and five (62.5 per cent) had bladder stones and two (25 per cent) had kidney stones, but there were no bile-duct stones; eight rats were fed for 101 to 122 days and six (75 per cent) had bladder stones, four (50 per cent) had kidney stones and two (25 per cent) had bile-duct stones; four rats were kept for 141 to 200 days and all (100 per cent) had bladder stones, three (75 per cent) had both kidney and bile-duct stones; five rats were kept for over 207 days and all (100 per cent) had bladder stones, four had both kidney and bile-duct stones. The following table shows the results in rats surviving more than 30 days:

N° de l'animal No. of animal	Sexe Sex	Poids — Body weight		Apparition de la xérophtalmie Symptom of xerophthalmia appears	Durée du régime Duration of feeding	Calculs — Calculi		
		Début de l'expér. Beginning of experiment	Fin de l'expér. End of experiment			Vessie Bladder	Rein Kidney	Voies biliaires Bile duct
		gr. — gms.	gr. — gms.	Jours — Days	Jours — Days			
2	♂	41	87	—	31	—	—	—
4	♂	41	49	4	31	+	—	—
5	♂	30	81	—	31	—	—	—
6	♂	26	46	—	31	—	—	—
7	♂	27	64	25	31	—	—	—
8	♂	41	112	—	31	—	—	—
13	♂	28	80	—	31	—	—	—
14	♀	29	83	—	31	—	—	—
15	♀	21	65	—	31	—	—	—
18	♀	30	69	—	31	—	—	—

N° de l'animal No. of animal	Sexe Sex	Poids — Body weight		Apparition de la xérophtalmie Symptom of xerophthalmia appears	Durée du régime Duration of feeding	Calculs — Calculi		
		Début de l'expér. Beginning of experiment	Fin de l'expér. End of experiment			Vessie Bladder	Rein Kidney	Voies biliaires Bile duct
		gr. — gms.	gr. — gms.	Jours — Days	Jours — Days			
19	♀	48	110	—	39	—	—	—
30	♀	31	70	—	31	—	—	—
49	♂	20	49	—	35	—	—	—
100	♀	26	53	—	35	—	—	—
111	♀	17	45	—	35	—	—	—
140	♂	40	66	21	35	+	—	—
38	♂	26	50	—	45	—	—	—
39	♂	35	67	35	45	+	—	—
40	♂	26	39	29	42	+	—	—
43	♂	31	77	—	42	—	—	—
44	♂	24	33	—	41	—	—	—
45	♂	24	45	—	43	—	—	—
46	♂	23	64	42	49	—	—	—
47	♂	35	51	—	42	—	—	—
53	♀	23	28	29	42	—	—	—
55	♀	25	56	34	49	+	—	—
60	♀	28	55	34	49	—	—	—
61	♀	29	100	—	45	—	—	—
65	♀	25	50	—	44	—	—	—
66	♀	39	61	—	42	—	—	—
70	♀	20	49	35	49	—	—	—
72	♀	36	58	—	45	—	—	—
78	♂	26	79	28	49	+	—	—
79	♂	30	80	—	48	—	—	—
80	♀	33	63	38	49	—	—	—
95	♂	41	87	—	49	—	—	—
96	♂	23	67	—	48	—	—	—
155	♀	43	98	14	42	+	—	—
162	♀	47	105	35	49	—	—	—
163	♀	32	44	16	48	—	—	—
164	♀	34	69	20	49	—	—	—
165	♀	46	69	42	43	—	—	—
166	♀	36	49	28	43	—	—	—
167	♀	50	101	29	42	—	—	—
169	♀	40	84	—	42	—	—	—
170	♀	41	79	28	47	—	—	—
54	♀	24	42	35	56	—	—	—
56	♀	26	56	35	56	—	—	—
58	♀	22	49	35	55	—	—	—
59	♀	26	66	35	57	+++	—	—
69	♀	25	69	45	56	—	—	—
83	♂	38	65	49	53	—	—	—
85	♂	25	51	48	56	+	—	—
87	♂	26	72	49	55	—	—	—

N° de l'animal No. of animal	Sexe Sex	Poids — Body weight		Apparition de la xérophtalmie Symptom of xerophthalmia appears	Durée du régime Duration of feeding	Calculs — Calculi		
		Début de l'expér. Beginning of experiment	Fin de l'expér. End of experiment			Vessie Bladder	Rein Kidney	Voies biliaires Bile duct
		gr. — gms.	gr. — gms.	Jours — Days	Jours — Days			
91	♀	28	80	48	56	—	—	—
92	♀	42	92	47	58	+	—	—
94	♀	35	94	49	56	+	—	—
103	♂	19	101	42	56	+	—	—
108	♀	25	82	—	54	—	—	—
122	♂	24	101	—	60	—	—	—
123	♀	34	196	—	59	—	—	—
73	♀	49	60	45	63	+	—	—
79	♀	37	70	48	70	—	—	—
129	♂	35	80	42	70	+	—	—
202	♀	24	103	35	61	—	—	—
205	♂	30	62	35	61	+	+	—
206	♀	32	72	39	61	+	+	—
218	♂	42	116	49	61	—	—	—
220	♀	37	115	—	61	—	—	—
77	♂	21	82	49	79	—	—	—
84	♂	27	130	53	77	—	—	—
110	♀	37	105	49	71	—	—	—
114	♀	26	104	55	77	—	—	—
1	♂	30	108	59	89	—	—	—
3	♂	37	89	45	89	—	—	—
27	♀	35	89	42	89	++	+	—
74	♀	32	61	70	88	+	—	—
76	♀	36	79	56	84	+	—	—
117	♂	30	172	—	84	—	—	—
226	♀	25	65	40	90	+	+	—
237	♂	39	85	67	94	+++	—	—
254	♂	41	120	39	115	—	—	—
255	♂	40	111	43	101	+++	—	—
257	♂	52	139	42	112	+++	+++	—
247	♀	37	129	39	115	++++	+++	+
248	♂	37	124	32	109	+++	++++	—
119	♂	37	165	112	121	++	—	—
231	♀	187	163	79	122	—	—	—
268	♂	50	122	52	122	+++	+++	+
230	♂	214	139	83	141	++	+	+
23	♂	25	171	92	154	+++	++	+
256	♀	35	161	49	163	++++	—	—
261	♂	32	147	39	171	+++	++	+
246	♀	39	95	26	210	++++	++++	++
249	♂	32	132	30	238	++++	++++	++++
251	♂	40	125	63	238	+++	+++	++
245	♀	30	93	46	207	++++	++++	++
276	♂	26	247	—	207	+++	—	—

In these experiments, too, bladder stones were found in a relatively short period, then kidney stones next, bile-duct stones taking the longest time.

Experiment III. — Rats fed on Vitamin B Deficient Diet.

Thirty-eight albino rats weighing 22 to 81 grams were fed on a vitamin B free diet. The diet was composed as follows:

	%
Dextrin	65
Casein	20
Olive oil	7
Cod-liver oil	3
Salt mixture	5

Besides these materials I gave daikon juice.

Ten out of 38 rats died within 29 days and 10 more died in 31 to 66 days; the 18 rats left were occasionally supplied with dried yeast in order to keep them alive, but two died within 90 days, 10 lived from 103 to 122 days and four lived over 200 days; none of them had calculi.

From these results, I can safely conclude that vitamin B has nothing to do with the formation of concretions.

Experiment IV. — Rats fed on Vitamin C Deficient Diet.

Fifty-six albino rats weighing 18 to 45 grams were fed on a vitamin C free diet for 21 to 283 days and examined for concretions. The food consisted of:

	%
Dextrin	65
Casein	18
Olive oil	7
Cod-liver oil	3
Salt mixture	5
Dried bottom yeast	2

It is well known that albino rats grow well without vitamin C. In this experiment, the rats grew normally and the final average weight of the males was 312 grams and of the females 195 grams (animals fed for over six months).

Among these animals I found no calculi except in one case. This rat showed symptoms of xerophthalmia on the 78th day of the experiment, but the symptoms disappeared within a week and it again showed xerophthalmia on the 92nd day; after two weeks it recovered and lived for 150 days.

Experiment V. — Rats fed on Vitamin B and C Deficient Diet.

Twenty-seven albino rats weighing 20 to 75 grams were fed on a vitamin B and C free diet for 4 to 169 days.

The food consisted of:

	%
Dextrin	65
Casein	20
Olive oil	7
Cod-liver oil	3
Salt mixture	5

Eight out of 27 rats died within a week but the other 19 rats lived for 10 to 169 days. The growth and appearance of these rats were just the same as in the case of Experiment III (vitamin B deficient diet). Five rats survived for 112 to 169 days, but showed no calculi.

From these experimental results, it seems to me that vitamin B and C have nothing to do with the formation of calculi.

Experiment VI. — Rats kept on a Normal Diet.

Twenty-six albino rats weighing 29 to 57 grams were fed on a normal diet, which was composed of:

	%
Dextrin	65
Casein	18
Olive oil	7
Cod-liver oil	3
Salt mixture	5
Dried bottom yeast	2

Besides these, daikon juice was given freely.

The duration of the experiment was 56 to 356 days; all the rats grew well and attained the normal weight and no calculi were found.

The bladder stones observed in animals fed on vitamin A or vitamin A and C deficient diet varied in size from particles no larger than grains of sand to masses as big as large beans; some of them were hard, others not so hard. The number of stones varied from one to 150 or more. The stones were situated in the bladder and also in the prostate gland. Some of them were smooth, others had rough and uneven surfaces and some were covered with spikes. The colour varied from a dirty white to a pale yellow or a dark brown. The dark-brown colour was on the surface only and the inside was either dirty white or pale yellow; when I found dark-brown stones I usually noticed the bladder full of blood.

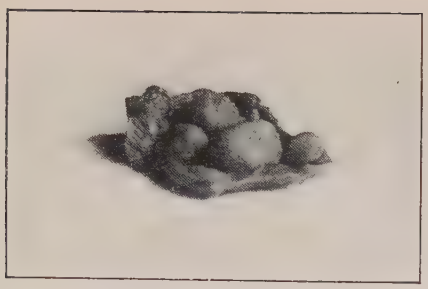
The kidney stones varied in size and in shape from that of a grain of Italian millet to that of a red bean. Some of them were fairly smooth and pyramid-like in shape, while others were uneven and rock-like. The colour was the same as in the bladder stones. The number varied from two or three to 20 or more.

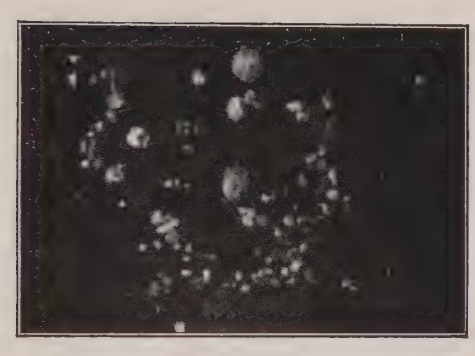
The bile-duct calculi varied in size from that of the head of a pin to that of a red bean. Some of them were uneven and some smooth and rather soft. The number varied from one or two to 40 or more. Their colour was the colour of bile. When bile-duct stones are formed, the orifice of the bile duct becomes closed and in most cases the ducts become enlarged to the size of a small lead pencil.

Repeated chemical examination of the urinary stones showed that they consisted mainly of phosphate of calcium and magnesium and triple phosphate, with traces of sodium, potassium and a small amount of mucoid substance. For example, in one bladder stone I found 55.7 per cent of P_2O_5 (calculated from dried sample). The bile-duct stones were found to consist mainly of cholesterol and pigment.

Summary.

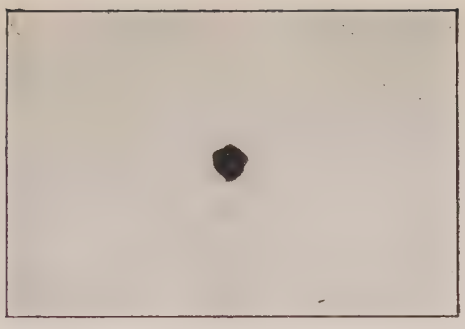
(1) Animals kept on a vitamin B deficient diet did not develop calculi.
(2) Animals kept on a vitamin C deficient diet did not develop calculi.
(3) Animals kept on a vitamin B and C deficient diet did not develop calculi.
(4) Animals kept on a normal diet did not develop calculi.
(5) Animals kept on a vitamin A deficient diet for a short time did not develop calculi.

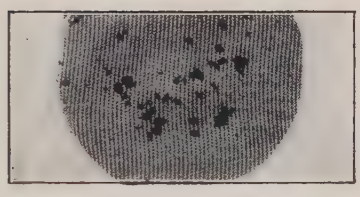




Bladder Stones (taken from white rats)

Kidney Stones (taken from a white rat).





Bile-duct Stones (taken from white rats).

(6) Animals fed on a vitamin A and C deficient diet for a short time did not develop calculi.

(7) Animals kept on a vitamin A deficient diet for a long period formed calculi. Bladder stones were formed in a relatively short period, next kidney stones, while bile-duct stones took the longest time to form.

(8) Animals kept on a vitamin A and C deficient diet for a long period formed calculi. In this case, too, bladder stones were formed in a relatively short period, netx kidney stones, while bile-duct stones took the longest time to form.

(9) The urinary calculi were phosphatic calculi.

(10) The biliary calculi were cholesterol stones.

Treatment for Experimental Calculi.

Rats fed on the vitamin A deficient diet, and vitamin A and C deficient diet, were examined for the presence of calculi by X-rays; six rats were selected, in which large bladder stones were found. Their diet was changed to a vitamin A rich diet consisting of:

	%
Dextrin	65
Casein	18
Olive oil	7
Cod-liver oil	3
Salt mixture	5
Dried bottom yeast	2

Daikon juice *ad libitum.*

Besides this diet I gave daily about 2 grams of dried river lamprey *(Entosphemis japonicus)*, although the animals took only 1 to 1½ gram a day. (According to our investigations dried river lamprey is very rich in vitamin A. 0.1 gram of dried river lamprey daily was sufficient to cure xerophthalmia in albino rats.) After the above diet was supplied the physiological condition of the animals was greatly improved and became almost normal.

One rat was kept on a vitamin A rich diet for two and a-half months and then killed and examined for calculi. Four of the bladder calculi had disappeared and a small one was left; this stone's edges were smooth and presented a number of smooth angles suggesting that it was disappearing. Three rats were kept on the same diet for three months and killed; no calculi were found, though in one case a soft cartilage-like substance was present. Two rats were kept for four and a-half months and killed; no stones were found.

One of the reasons why the bladder stones disappeared was probably that the urine had changed to an acid from an alkaline reaction. It was found that, in the case of the rats fed on the vitamin A or vitamin A and C deficient diet, the urine changed to an alkaline reaction.

The author takes this opportunity of expressing his indebtedness to Dr. Tadasu Saiki, Director of the Imperial State Institute for Nutrition, for his encouragement in this work and for much valuable advice during its progress. He also wishes heartily to thank Messrs. H. Matsumuro and Y. Shimoda for their valuable assistance throughout the experiments.

II.

In the first report I discussed the formation of phosphatic and cholesterol concretions in animals kept on vitamin A and also vitamin A and C deficient diets

for a long period. In the following experiments I attempted to find out the influence of protein and inorganic phosphorus and calcium on the formation of the stones and also the chemical nature of the concretions.

Experiment I. — Animals fed on the Protein and Vitamin A Deficient Diet.

Twenty albino rats weighing 24 to 35 grams were fed on the following protein and vitamin A deficient diet for three to 103 days:

	%
Dextrin	83
Olive oil	10
Salt mixture	5
Dried bottom yeast	2
Daikon juice *ad libitum.*	

(In this diet there is 2 per cent of dried bottom yeast and therefore 1.4 per cent of protein.)

Fourteen rats died within a month; there were two cases (14 per cent) of bladder stones but no other stones were found.

Six rats died within 31 to 103 days; there were two cases (33 per cent) of bladder stones and one case (16 per cent) of bile-duct stones, but no kidney stones were found.

Chemical analysis showed that the urinary stones consisted of phosphates and a protein-like substance.

Experiment II. — Rats fed on the Protein Deficient Diet.

Twenty albino rats weighing from 24 to 137 grams were fed on the protein deficient diet for three to 101 days. The food consisted of:

	%
Dextrin	83
Olive oil	7
Cod-liver oil	3
Salt mixture	5
Dried bottom yeast	2
Daikon juice *ad libitum.*	

(In this diet there are 2 per cent of dried bottom yeast and therefore 1.4 per cent of protein.)

Eighteen out of 20 rats died in three to 47 days and the other two lived 100 days and 101 days respectively, but no calculi were found.

Experiment III. — Rats fed on the Vitamin A and Inorganic Calcium and Phosphorus Deficient Diet.

Twenty albino rats weighing from 24 to 60 grams were kept on the vitamin A and inorganic calcium and phosphorus deficient diet for seven to 64 days. The food was composed of:

	%
Dextrin	68.85
Casein	18.00
Olive oil	10.00
Dried bottom yeast	2.00
Salt mixture	1.15
Daikon juice *ad libitum.*	

The salt mixture consisted of:

	%
NaCl	7
$MgSO_4H_2O$	13
Fe-citrate	3
Trace of KI.	

Seventeen out of 25 rats died within 30 days and among them one case (6 per cent) of bladder and kidney stones and two cases (12 per cent) of bile-duct stones were found. The other eight rats lived for 31 to 64 days; among them six cases (75 per cent) of bladder and bile-duct stones and four cases (50 per cent) of kidney stones were found.

The formation of calculi is shown in the following table (rats fed over 30 days).

N° de l'animal No. of animal	Sexe Sex	Poids Body weight		Apparition de la xérophtalmie Symptom of xerophthalmia	Durée du régime Duration of feeding	Calculs — Calculi		
		Début de l'expérience Beginning of experiment	Fin de l'expérience End of experiment			Vessie Bladder	Rein Kidney	Voies biliaires Bile duct
		gr. — gms.	gr. — gms.	Jours — Days	Jours — Days			
2	♂	60	51	28	42	++++	+++	++++
3	♂	60	83	29	64	—	—	+++
5	♀	51	60	27	46	++	++	+++
6	♀	37	42	28	44	++++	++++	+++
7	♀	54	63	35	40	++++	—	—
8	♀	43	61	28	49	—	—	—
10	♂	46	61	35	52	+++	—	+++
15	♂	59	60	30	60	++++	++++	++++

As shown in the table, bile-duct stones were formed in a rather shorter time than bladder stones, and kidney stones were formed last of all.

The urinary calculi found in the animals fed on the vitamin A and inorganic calcium and phosphorus deficient diet consisted mainly of carbonate; the bile-duct stones consisted of an abundance of calcium salts together with cholesterol and pigment.

Summary.

(1) Animals kept on the protein and vitamin A deficient diet formed concretions is a relatively short period (shorter period than those fed on either the vitamin A deficient or the vitamin A and C deficient diets).

(2) Animals fed on the protein deficient diet did not form calculi.

(3) Animals fed on the vitamin A and inorganic P and Ca deficient diet formed calculi in a very short time. In these cases bile-duct stones were formed first and then bladder stones, kidney stones taking the longest time of all.

(4) The urinary calculi found among the animals fed on the vitamin A and inorganic P and Ca deficient diets were carbonate calculi, while the calculi of the animals fed on the vitamin A and vitamin A and C deficient diets were phosphatic. The bile-duct calculi consisted of abundant calcium salts with cholesterol and pigment.

22.

FORMATION OF GASTRIC CARCINOMA IN ALBINO RATS FED ON DEFICIENT DIETS.

By Yoshitomo Fujimaki
(From the Imperial State Institute for Nutrition, Tokyo).

Although a number of investigators have been working on deficiency diseases, I have not yet heard of the production of carcinoma in albino rats by feeding them with diets deficient in vitamin A.

The constituents of the diet and the methods of feeding used at the Imperial State Institute for Nutrition are different from others. We have paid special attention to the purification of the food materials in order to eliminate all vitamins as far as possible; we have also paid special attention to the combination and proportion of food materials (such as casein, dextrin, olive oil, salt mixture and dried bottom yeast). In order that young rats might survive for a long period, they were fed on a diet rich in vitamin A whenever symptoms of xerophthalmia appeared, or when they became weak.

The rats so treated developed carcinoma, which is not ordinarily observed when they are fed continuously on a vitamin A deficient diet. If the above procedure is not carried out, the young rats do not survive long enough for the formation of carcinoma. Well-grown rats, on the other hand, do occasionally survive long enough for carcinoma to form.

During autopsies on animals fed for long periods on vitamin A deficient or poor diets, I recognised special changes in the stomach. I noticed especially a circumscribed thickening with multiple scattered ulcers. I showed and explained these results to Director Saiki; we exchanged opinions concerning them and I then continued the experiments very carefully.

On March 17th, 1925, I found what appeared to be a tumour; this was macroscopically examined and diagnosed as carcinoma. The histological work was done by Dr. Kimura and his assistant Dr. Wada, of Jikeikwai Medical College. The author wishes to take this opportunity of expressing his appreciation of their kind assistance.

A preliminary report was presented by Fujimaki and Masaki at the fifteenth meeting of the Imperial State Institute for Nutrition on June 11th, 1925.

The following experiments were performed to show the relationship between the formation of cancer and nutrition.

Preparations for the Experiments.

1. *Diet for Experimental Animals.*

The diet must contain all the necessary nutritive elements except those being investigated and must be adequate to supply the necessary energy; it must also be

digestible and palatable. By the term " perfect diet " we mean a diet which contains an adequate amount of protein, carbohydrate, fat, mineral salts and vitamins. However, before we prepare a diet with these materials, they must be purified. I paid a great deal of attention to the purification, using the following procedures:

(a) *Casein used as a source of protein.*

Seven or eight pounds of casein were boiled for five or six hours with two to three times its volume of 90 to 95% alcohol on a water bath, using a reflex condenser to prevent the evaporation of alcohol. During the extraction the casein was stirred constantly by a motor. The mixture was filtered with a suction pump and the casein was well washed with alcohol. This procedure was repeated from two to three times, after which the casein was dried and ground to a powder.

(b) *Dextrin used as a source of carbohydrate.*

Dextrin was treated in exactly the same way as casein.

(c) *Olive oil used as a source of fat.*

According to some authorities, olive oil does not contain vitamin A; I am not convinced of the truth of this statement. In my work it was used merely as a source of fat, and, in order to eliminate any vitamin A, I heated the oil twice to 160° to 170° C. for several hours each time. During the heating the oil was stirred continuously.

(*d*) I obtained bottom yeast from a brewing company, added a large amount of cold tap water, stirred well and then let it stand for several minutes till the yeast precipitated. The yeast was then washed all night and the hops were strained off by means of a silk sieve. The yeast was compressed and dried by an air dryer, then ground to a powder.

2. *Composition of Food Mixture.*

The foods furnished to the experimental rats consisted of isolated food materials purified by the above methods; they were mixed in the following proportions:

(*a*) Vitamin A deficient diet:

	%
Dextrin	65
Casein	18
Olive oil	10
Yeast	2
Salt mixture	5

The salt mixture was composed of the following salts:

	%
NaCl	6.5
$MgSO_4H_2O$	13.0
$NaHPO_4H_2O$	10.0
$K_2HPO_4H_2O$	30.0
Ca-lactate	37.0
Fe-citrate	3.0

A trace of KI.

(*b*) Vitamin A and protein deficient diet:

	%
Dextrin	83
Olive oil	10
Salt mixture	5
Yeast	2

The salt mixture was the same as in (*a*).

In this diet there was 2 per cent of dried bottom yeast and therefore 1.4 per cent of protein.

(*c*) Vitamin A and inorganic calcium and phosphorus deficient diet:

	%
Dextrin	68
Casein	18
Olive oil	10
Yeast	2
Salt mixture	2

The salt mixture was composed of the following salts:

	%
NaCl	7
$MgSO_4H_2O$	13
Fe-citrate	3

A trace of KI.

(*d*) Normal diet:

	%
Dextrin	67
Casein	18
Olive oil	7
Cod-liver oil	3
Salt mixture	5

Daikon or its juice *ad libitum*.

The salt mixture was the same as in (*a*).

Selection of Animals and Feeding.

For these experiments I selected young and well-grown albino rats. The young rats do not survive long on the diets mentioned above; therefore I fed them occasionally with a normal diet in order to keep them alive. Most of the well-grown rats survived for a long time, though some did not survive longer than two months. Occasionally one of the well-grown rats would become weak and show symptoms of xerophthalmia; it was then given the normal diet, which improved its physical condition, and I again fed it with the deficient diet mentioned above.

The duration of the feeding of the rats with the vitamin A deficient diet was from two to twelve months, with the vitamin A and protein deficient diet from one to four months, and with the diet deficient in inorganic calcium, phosphorus and vitamin A from two to five months. Each rat was kept in a separate and clean cage.

The foods were changed four times a week, each rat being given a freshly prepared diet. The body weight was taken twice a week at a definite time.

Pathological Changes.

1. *Macroscopical Observations.*

Here I will summarise the pathological changes found in the stomachs. Quite frequently there were hæmorrhages, and the stomach was often full of blood. In the fore-stomach I frequently found pale greyish circumscribed thickenings; there might be two or three, or even twenty or more, and they were the size of grains of Italian millet or frequently as large as green peas. The centre of these circumscribed thickenings was sunken or concave. At the junction of the fore-stomach and main stomach were frequently recognised papillomata and islands of tissue showing an unusual thickening. In the main stomach, I often found dark pinkish circumscribed concave masses varying in number from one or two to fifty or even more. Several of the stomachs were full of growth.

2. *Microscopical Observations.*

To supplement the results of macroscopic examination, microscopical examinations were made by Professor Tetsuji Kimura, of Jikeikwai Medical College. The author wishes to take this opportunity of expressing his appreciation of his kind aid.

In some specimens there were slight changes indicating a keratinising process, while in others a definite hyperkeratosis was observed. In the upper layers of flat cells were observed intensive growths of connective tissue and epithelium which were either of an atypical or papillomatous form, or represented a heterotypical growth of the germinal layer. Some of these extended into the sub-mucosa and the muscular layer in this region was atrophied.

From the above observations I draw these conclusions: carcinoma or carcinomatosis begins as a hyperkeratosis which goes on to papilloma formation; heterotypical extension then occurs and finally there is a conspicuous destructive extension of cell growth which appears to be cancerous transformation.

In experimental carcinoma we must consider two different causes: (1) a constitutional cause, (2) a local cause.

Up to the present time, experimental cancer or tumour has been always thought of as the result of some local irritation; for instance, Fibiger produced experimental gastric carcinoma by local irritation, using a parasite called *Speroptera neoplastica* or *gongyloma neoplasticum*; Professors Yamagiwa and Ichikawa produced cancer on a rabbit's ear by smearing it with coal tar. Other investigators have performed similar experiments with like results; in all, the main stress has been laid on local irritation as the cause, and constitutional causes have usually been neglected.

Fibiger was the first man to produce experimental cancer in the stomach of white rats, and many investigators have since produced cancer or tumour-like growths in these animals. However, all these growths resulted from local irritation acting for a long time; a chronic hyperplastic inflammation first took place, which later became a malignant or non-malignant tumour. In my experiments the first stage of inflammation, which is found when cancer results from local irritation, was not present, but the last stages were similar and cancer was eventually produced. However, in the last stage some inflammation may be found.

In conclusion, the reasons why we claim that there is a definite relationship between the vitamin A free diet and the pathological changes of the stomach are as follows:

1. Rats fed on a normal diet have been found by all investigators to be usually free from either a keratinising process or tumour formation, but when

given the deficiency diets mentioned above we almost always found in them a keratinising process and frequently carcinoma.

2. During the experimental periods, I did not initiate any local irritation either mechanically or chemically.

3. When rats were fed with a vitamin A free diet, the various epithelia were transformed into stratified squamous keratinising epithelium; this process has already been described by various workers as occurring in the eye-ball, oral cavity, nasal passage, larynx, trachea and bronchi, pancreas, renal pelvis, seminal vessels, epididymis, prostate gland, ovaries, oviducts and uterus. In some of the above organs I have observed carcinoma macroscopically.

From the above results, I conclude that a vitamin A free diet has a definite relationship with the formation of carcinoma.

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